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A

DICTIONARY

OF

CHEMISTRY,

IN WHICH

THE PRINCIPLES OF THE SCIENCE ARE INVESTIGATED ANEW,
AND ITS APPLICATIONS TO THE PHENOMENA OF NATURE, MEDICINE,
MINERALOGY, AGRICULTURE, AND MANUFACTURES,
DETAILED.

BY ANDREW URE, M. D. F. R. S.
PROFESSOR OF THE ANDERSONIAN INSTITUTION, MEMBER OF THE GEOLOGICAL AND
ASTRONOMICAL SOCIETY OF LONDON, &c. &c. &c.

WITH AN

Introductory Dissertation;

CONTAINING

INSTRUCTIONS FOR CONVERTING THE ALPHABETICAL ARRANGEMENT INTO
A SYSTEMATIC ORDER OF STUDY.

THIRD EDITION,
WITH NUMEROUS ADDITIONS AND CORRECTIONS.

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1828.

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1828

TO

THE RIGHT HONOURABLE

THE EARL OF GLASGOW,

BARON ROSS OF HAWKHEAD,

&c. &c. &c.

LORD-LIEUTENANT OF AYRSHIRE.

MY LORD,

WHEN I inscribe this volume to your Lordship, it is neither to offer the incense of adulation, which your virtues do not need, and your understanding would disdain; nor to solicit the patronage of exalted rank to a work, which in this age and nation must seek support in scientific value alone. The present dedication is merely an act of gratitude, as pure on my part, as your Lordship's condescension and kindness to me have been generous and unvarying. At my outset in life, your Lordship's distinguished favour cherished those studious pursuits, which have since formed my *chief* pleasure and business; and to your Lordship's hospitality I owe the elegant retirement, in which many of the following pages were written. Happy would it have been for their readers, could I have transfused into them a portion of that grace of diction, and elevation of sentiment, which I have so often been permitted to admire in your Lordship's family.

I have the honour to be,

My LORD,

Your Lordship's most obedient

And very faithful Servant,

ANDREW URE.

GLASGOW,
November 7, 1828.

ical inquiry; nay, hardly a trace of the genius of discovery, or of the
me career which it has run. The unhoped for, and in too many
cts unmerited, success of this Dictionary may possibly be attributed
e models of inventive research, which I was careful to transfer into
ages from the master-memoirs of the modern school. He who can
mplate these without emotion need never hope to emulate the achieve-
s or renown of their authors.

e same plan has been pursued with regard to the new additions just
to this work; as the reader will perceive on consulting the articles
ric acid; Ferrocyanic acid, with the *Ferroprussiates; Sulpho-naph-*
acid; Sulphovinic; Titanic, &c.: as also *Boron; Brome,* with its
ounds; *Cyanogen; Hydrogen; Indigo; Light; Meteorite; Mor-*
; *Nickel; Nitrogen; Oil gas; Oil of Wine; Phosphuretted Hydro-*
Silicium; Sulphurets; Titanium, and many others. The two
now introduced under EQUIVALENTS (CHEMICAL) will furnish
ble aids to the chemical student, affording him a key to the writings
rzelius, which he might otherwise find unintelligible, as also to those
r chemists who adopt hydrogen for their atomic unity. My own
lections, indeed, are in favour of this scale; but the oxygen one was
terwoven with the former editions of the Dictionary that I did not
it expedient to eradicate what many of our most eminent philosophers,
Dr. Wollaston at their head, still prefer. By this means too the three
iling atomic systems are laid before my readers.

ne may imagine that I might have imitated other modern compilers,
ave saved myself the labour of canvassing the weights of many of the
, by adopting the numbers given by Dr. Thomson in his recent pub-
n on the First Principles of Chemistry. I have examined this work
ttention. It displays the characteristic industry and ingenuity of the
r. But the never failing concurrence, even to the second or third
al place, of his experimental numbers, with the multiple numbers of
gen—a general fact which he seeks to establish—appears to me a
ion in practice far beyond the present reach of human hands.
rout's proposition of the atomic weights of chemical bodies, being all
ples of that of hydrogen, by a whole number, is a very probable idea;
e must beware of suffering our hypothetical notions to influence our
ciation of experimental results. I humbly apprehend that Dr. Thom-
nder the power of this illusion, has vitiated many of the most
tant subjects of our science; of which, unexceptionable and very
g evidence will be found under the articles ACID (FLUORIC) and
PHURETTED HYDROGEN. Many of the numbers adopted by him

coincide with those deducible from the prior researches of British and foreign chemists. A few he has no doubt rectified in the course of his numerous trials of saline decompositions. I have admitted some of these into my general table of SALTS.

The more extensive the range which we take among the original memoirs of the eminent chemists of this and the immediately preceding age, the more defects we shall observe in our modern compilations. The best of these, indeed, can be regarded merely as brief summaries; and the most curiously methodical as a collection of facts and reasonings broken down into fragments, fitted to a tesselated system, certainly not very like the system of nature. Hence, the former collections, though valuable in many respects, will never quench the ardent thirst of knowledge; while the latter can hardly fail to perplex the common mind. Moreover, in many fields of chemical literature the English language is entirely barren. Is it to be believed, that in a country whose the iron trade, if not its staple, is the basis of all its manufactures, there should not exist any separate treatise on iron, its ores, and steel? The Germans possess about fifteen respectable works on these subjects. There is no English book on metallurgy, a business in an immense British capital is engaged. The experienced chemical manufacturer laughs, as he well may, at most of our essayists on the chemical arts, the processes prescribed by whom, if pursued in practice, would soon involve their dupes in bankruptcy.

Let those who think this censure too severe seek for answers in our books to the following questions on the primary chemical art, the formation of sulphuric acid:

What is the just quantity of sulphur to be burned daily, relative to the capacity of the leaden chamber?

Whether is the continuous or intermitting combustion most productive?

What is the proper temperature to be maintained in the chamber?

What are the operation and effect of introducing steam?

At what stage of the combustion, and to what extent, ought it to be admitted?

To what degree of density is it advantageous to carry the acid in the chamber?

Whether should the sulphur and nitre be mixed prior to combustion, or the sulphur be set on fire by itself, the nitre being placed in a pot over its flame?

Similar questions, of equal importance, may be put on many other chemical arts, of which satisfactory explanations will be vainly sought for in books. These, indeed, present but a slight examination of the principles of the processes, if any at all, and seldom or never calculate proportions or results. As far as relates to the arts, they are, it must be confessed, hereditary transcriptions.

To supply such *desiderata* in our chemical literature is an undertaking peculiarly arduous, of which the entire accomplishment cannot be expected from a single mind. Yet diligence may do much; and will not be disappointed of its reward, though much should remain undone. Under this conviction, I have for many years been collecting materials for such a body of chemical knowledge, and having matured my plans, I am now preparing it for the press. Though comprehensive, it will not be cumbersome; for it will be so subdivided as to furnish students with a copious elementary text-book; manufacturers with explicit rules for conducting their respective arts; practical chemists with an ample *tableau raisonné* of the methods and resources of analytical science; and, finally, general readers with developments of natural phenomena, presenting simplified modes of examining the productions of nature, and of readily ascertaining the constituents of earthy minerals, mineral waters, ores, and soils.

Glasgow, October 30, 1827.

INTRODUCTION.

In this Introduction I shall present a GENERAL VIEW of the objects of chemistry, along with a scheme for converting the alphabetical arrangement adopted in this volume into a systematic order of study.

The forms of matter are numberless, and subject to incessant change. Amid all this variety, which perplexes the common mind, the eye of science discerns a few unchangeable primary bodies, by whose reciprocal actions and combinations this marvellous diversity and rotation of existence are produced and maintained. These bodies, having resisted every attempt to resolve them into simpler forms of matter, are called *undecompounded*, and must be regarded in the present state of our knowledge as *experimental elements.* It is possible that the elements of *nature* are very dissimilar; it is probable that they are altogether unknown; and that they are so recondite, as for ever to elude the sagacity of human research.

The primary substances which can be subjected to measurement and weight are fifty-two in number. To these, some chemists add the imponderable elements,—light, heat, electricity, and magnetism. But their separate identity is not clearly ascertained.

Of the fifty-two ponderable principles, four, possibly five, require a distinct collocation from the marked peculiarity of their powers and properties. These are named *Chlorine*, *Oxygen*, *Iodine*, *Fluorine*, and *Bromine*. These bodies display a pre-eminent activity of combination, an intense affinity for most of the other forty-seven bodies, which they corrode, penetrate, and dissolve; or, by uniting with them, so impair their cohesive force, that they become friable, brittle, or soluble in water, however dense, refractory, and insoluble they previously were. Such changes, for example, are operated on platinum, gold, silver, and iron, by the agency of chlorine, oxygen, or iodine. But the characteristic feature of these archeal elements is this, that when a compound consisting of one of them, and one of the other forty-seven more passive elements, is exposed to voltaic electrization, the former is uniformly evolved at the positive or vitreo-electric pole, while the latter appears at the negative or resino-electric pole.

The singular strength of their attractions for the other simple forms of matter is also manifested by the production of heat and light, or the phenomenon of combustion, at the instant of their mutual combination. But this phenomenon is not characteristic; for it is neither peculiar nor necessary to their action, and, therefore, cannot be made the basis of a logical arrangement. Combustion is vividly displayed in cases where none of these primary dissolvents is concerned. Thus certain metals combine with others with such vehemence as to elicit light and heat; and many of them, by their union with sulphur, even *in vacuo*, exhibit intense combustion. Potassium burns distinctly in cyanogen (carburetted azote), and splendidly in sulphuretted hydrogen. For other examples to the same purpose, see COMBUSTIBLE and COMBUSTION.

And again, the phenomenon of flame does not necessarily accompany any of the actions of oxygen, chlorine, and iodine. Its production may be regulated at the pleasure of the chemist, and occurs merely when the mutual combination is rapidly effected. Thus chlorine or oxygen will unite with hydrogen, either silently and darkly, or with fiery explosion, as the operator shall direct.

Since, therefore, the quality of exciting or sustaining combustion is not peculiar to these electro-positive elements; since it is not indispensable to their action on other substances, but adventitious and occasional, we perceive the inaccuracy of that classification which sets these three or four bodies apart under the denomination of *supporters of combustion;* as if combustion could not be supported without them, and as if the support of combustion was their indefeisible attribute, the essential concomitant of their action. On the contrary, every change which they can produce, by their union with other elementary matter, may be effected *without* the phenomenon of combustion. See section 5th of article COMBUSTION.

The other forty-seven elementary bodies have, with the exception of azote (the solitary incombustible), been grouped under the generic name of *combustibles.* But in reality combustion is independent of the agency of all these bodies, and therefore *combustion may be produced without any combustible.* Can this absurdity form a basis of chemical classification? The decomposition of euchlorine, as well as of the chloride and iodide of azote, is accompanied with a tremendous energy of heat and light; yet no combustible is present. The same examples are fatal to the theoretical part of Black's celebrated doctrine of latent heat. His facts are, however, invaluable, and not to be controverted, though the hypothetical thread used to connect them be finally severed.

To the term *combustible* is naturally attached the idea of the body so named affording the heat and light. Of this position, it has been often remarked, that we have no evidence whatever. We know, on the other hand, that oxygen, the incombustible, could yield, from its latent stores, in Black's language, both the light and heat displayed in combustion; for mere mechanical condensation of that gas, in a syringe, causes their disengagement. A similar condensation of the combustible hydrogen occasions, I believe, the evolution of no light. From all these facts it is plain, that the above distinction is unphilosophical, and must be abandoned. In truth, every insulated or simple body has such an appetency to combine with, or is solicited with such attractive energy by, other forms of matter, whether the actuating forces be electo-attractive or electrical, that the motion of the particles constituting the change, if sufficiently rapid, may always produce the phenomenon of combustion.

Of the forty-seven electro-negative elements, forty-one are metallic, and six non-metallic. The latter group may be arranged into three pairs:—

1*st*, The gaseous bodies, HYDROGEN and AZOTE;

2*d*, The fixed and infusible solids, CARBON and BORON.

3*d*, The fusible and volatile solids, SULPHUR and PHOSPHORUS.

The forty-one metallic bodies are distinguishable by their habitudes with oxygen, into two great divisions, the BASIFIABLE and ACIDIFIABLE metals. The former are thirty-four in number, the latter seven.

Of the thirty-four metals, which yield by their union with oxygen salifiable bases, three are convertible into alkalis, nine into earths, and twenty-two into ordinary metallic oxides. Some of the latter, however, by a maximum dose of oxygen, seem to graduate into the acidifiable group, or at least cease to form salifiable bases.

We shall now delineate a general chart of Chemistry, enumerating its various leading objects in a somewhat tabular form, and pointing out their most important relations, so that the readers of this Dictionary may have it in their power to study its contents in a systematic order.

CHEMISTRY

is the science which treats of the specific differences in the nature of bodies, and the permanent changes of constitution to which their mutual actions give rise.

This diversity in the nature of bodies is derived either from the AGGREGATION or COMPOSITION of their integrant particles. The state of *aggregation* seems to depend on the relation between the cohesive attraction of these integrant particles, and the antagonizing force of heat. Hence, the three general forms of *solid*, *liquid*, and *gaseous*, under one or other of which every species of material being may be classed.

For instruction on these general forms of matter, the student ought to read, 1st, The early part of the article ATTRACTION; 2d, CRYSTALLIZATION; 3d, That part of CALORIC entitled, "Of the change of *state* produced in bodies by caloric, independent of change of composition." He may then peruse the introductory part of the article GAS, and BALANCE, and LABORATORY. He will now be sufficiently prepared for the study of the rest of the article CALORIC, as well as that of its correlative subjects, TEMPERATURE, THERMOMETER, EVAPORATION, CONGELATION, CRYOPHORUS, DEW, and CLIMATE. The order now prescribed will be found convenient. In the articles CALORIC, there are a few discussions which the beginner may perhaps find somewhat difficult. These he may pass over at the first reading, and resume their consideration in the sequel. After Caloric he may peruse LIGHT, and the first three sections of ELECTRICITY.

The article COMBUSTION will be most advantageously examined, after he has become acquainted with some of the diversities of COMPOSITION; viz. with the four electro-positive dissolvents, oxygen, chlorine, bromine and iodine; and the six non-metallic electro-negative elements, hydrogen, azote, carbon, boron, sulphur, and phosphorus. Let him begin with *oxygen*, and then peruse, for the sake of connexion, *hydrogen* and *water*. Should he wish to know how the specific gravity of gaseous matter is ascertained, he may consult the fourth section of the article GAS.

The next subject to which he should direct his attention is CHLORINE; on which he will meet with ample details in the present Work. This article will bear a second perusal. It describes a series of the most splendid efforts ever made by the sagacity of man, to unfold the *chemical mysteries* of nature. In connexion with it he may read the articles CHLOROUS and CHLORIC OXIDES, or the protoxide and deutoxide of Chlorine. Let him next study the copious article Iodine from beginning to end.

Carbon, boron, sulphur, phosphorus, and azote, must now come under review. Related closely with the first, he will study the *carbonous oxide*, *carburetted* and *subcarburetted hydrogen*. What is known of the element *boron* will be speedily learned; and he may then enter on the examination of *sulphur*, *sulphuretted hydrogen*, and *carburet of sulphur*. *Phosphorus* and *phosphuretted hydrogen*, with *nitrogen* or *azote*, and its *oxides* and *chlorides*, will form the conclusion of the first division of chemical study, which relates to the elements of most general interest and activity. The general articles *Combustible*, *Combustion*, and *Safe-Lamp* may now be read with advantage; as well as the remainder of the article *Attraction*, which treats of affinity.

Since in the present work the *alkaline* and *earthy salts* are annexed to their respective *acids*, it will be proper, before commencing the study of the latter, to become acquainted with the alkaline and earthy bases.

The order of reading may therefore be the following: first, The general article *alkali*, then *potash* and *potassium*, *soda* and *sodium*, *lithia* and *ammonia*. Next, the general article *earth*; afterwards *calcium* and *lime*, *barium* and *barytes*, *strontia*, *magnesia*, *alumina*, *silica*, *glucina*, *zirconia*, and *yttria*.

Let him now peruse the general articles *acid* and *salt*; and then the *non-metallic* oxygen acids, with their subjoined salts, in the following order:—*sulphuric*, *sulphurous*; *hyposulphurous*, and *hyposulphuric*; *phosphoric*, *phosphorous*, and *hypophosphorous*;

carbonic and *chlorocarbonous*; *boracic*; and lastly, the *nitric* and *nitrous*. The others may be studied conveniently with the hydrogen group. The order of perusing them may be, the *muriatic* (hydrochloric of M. Gay Lussac), *chloric*, and *perchloric*; the *hydriodic*, *iodic*, and *chloriodic*; the *fluoric*, *fluoboric*, and *fluosilicic*; the *prussic* (hydrocyanic of M. Gay Lussac), *ferroprussic*, *chloroprussic*, and *sulphuroprussic*. The *hydrosulphurous* and *hydrotellurous* are discussed in this Dictionary, under the names of *sulphuretted hydrogen*, and *telluretted hydrogen*. These compound bodies possess acid powers, as well perhaps as arsenuretted hydrogen. It would be advisable to peruse the article *cyanogen* either before or immediately after *prussic acid*.

As to the vegetable and animal acids, they may be read either in their alphabetical order, or in any other which the student or his teacher shall think fit.

The metallic acids fall naturally under metallic chemistry; on the study of which I have nothing to add to the remarks contained in the general article METAL. Along with each metal in its alphabetical place, its native state, or *ores*, may be studied. See ORES.

The chemistry of organized matter may be methodically examined by perusing, first of all, the article *vegetable kingdom*, with the various products of vegetation there enumerated; and then the article *animal kingdom*, with the subordinate animal products and *adipocere*.

The article *analysis* may be now consulted; then *mineral* WATERS; *equivalents* (*chemical*), and analysis of *ores*.

The mineralogical department should be commenced with the general articles *mineralogy* and *crystallography*; after which the different species and varieties may be examined under their respective titles. The enumeration of the *genera* of M. Mohs, given in the first article, will guide the student to a considerable extent in their methodical consideration. Belonging to mineralogy, are the subjects *blowpipe*, *geology*, with its subordinate *rocks*, *ores*, and *meteorite*.

The *medical* student may read with advantage the articles *acid* (*arsenious*), *antimony*, *bile*, *blood*, *calculus* (urinary), the sequel of *copper*, *digestion*, *gall-stones*, *galvanism*, *intestinal concretion*, *lead*, *mercury*, *poisons*, *respiration*, *urine*, *&c.*

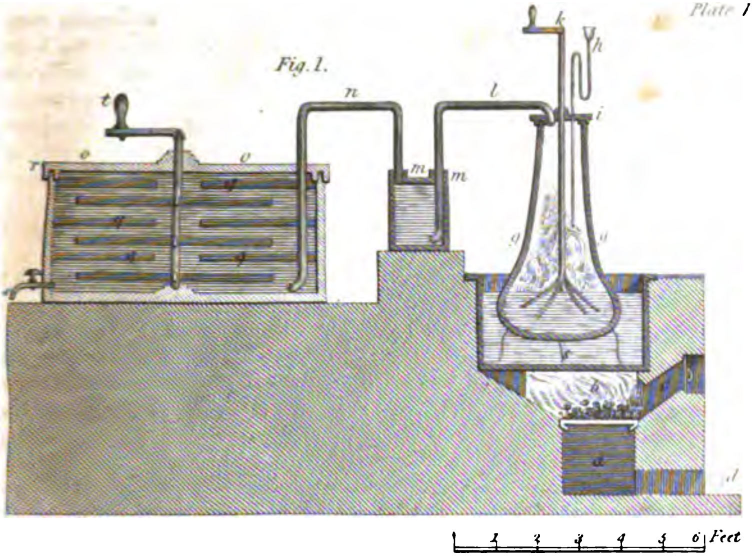
The *agriculturist* will find details not unworthy of his attention, under the articles *absorbent*, *analysis* of soils, *carbonate*, *lime*, *manure*, and *soils*.

Among the discussions interesting to *manufacturers* are, *acetic* and other *acids*, *alcohol*, *alum*, *ammonia*, *beer*, *bleaching*, *bread*, *caloric*, *chloride of* LIME, *coal*, *coal-gas*, *distillation*, *dyeing*, *ether*, *fat*, *fermentation*, *glass*, *ink*, *iron*, *ores*, *potash*, *pottery*, *salt*, *soap*, *soda*, *steel*, *sugar*, *tanning*, *&c.*

The *general* reader will find, it is hoped, instruction, blended with entertainment, in the articles *aërostation*, *air*, *climate*, *combustion*, *congelation*, *dew*, *electricity*, *equivalents*, *galvanism*, *geology*, *light*, *meteorolite*, *rain*, and several other articles formerly noticed.

CHEMICAL APPARATUS.

Plate I.



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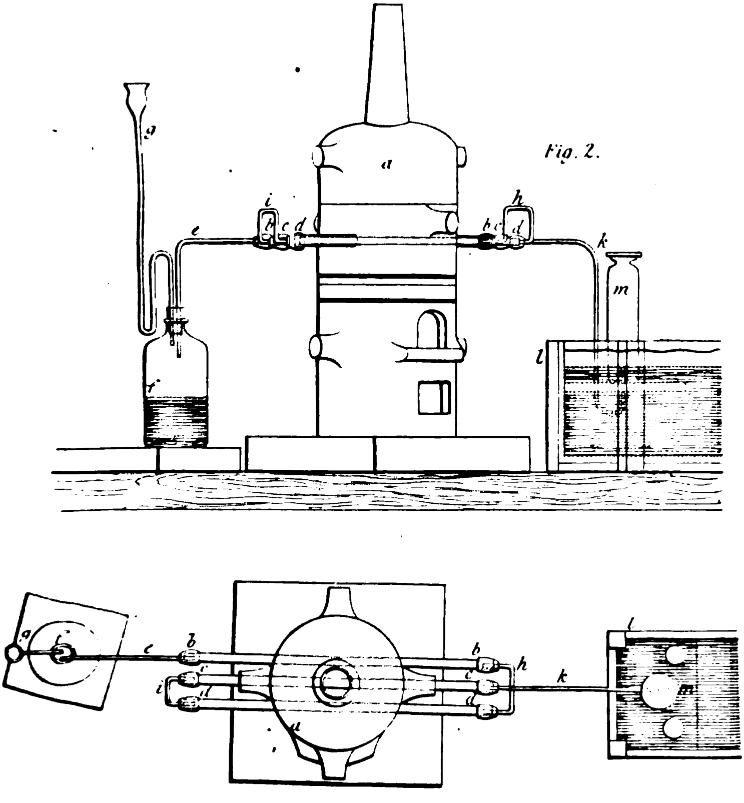

Fig. 2.

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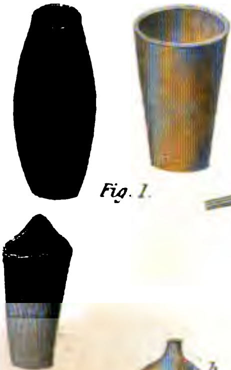
Plate II.



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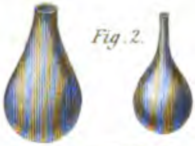

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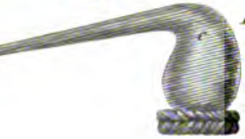

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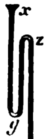
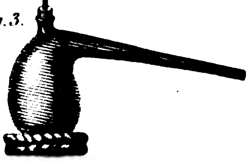

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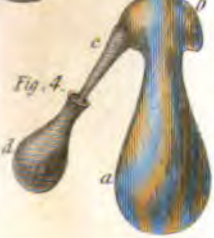

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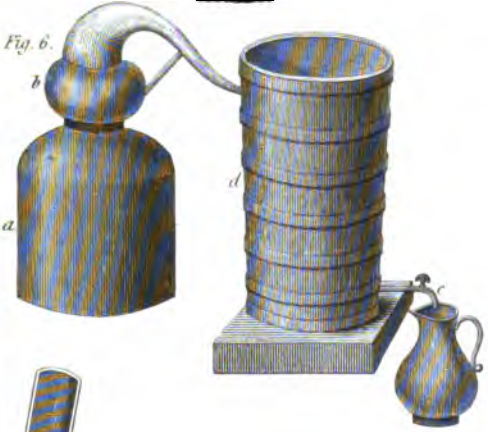

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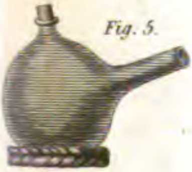

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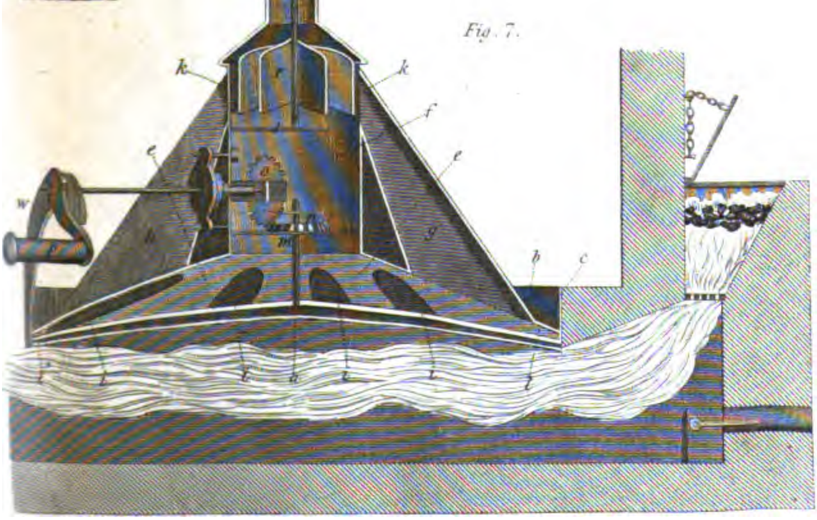
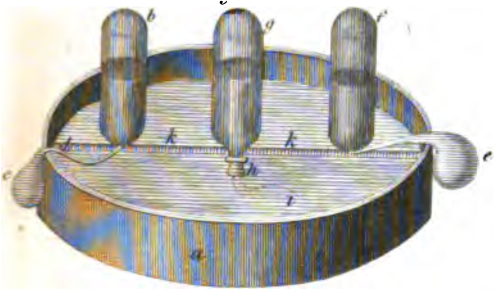


Fig. 7.

CHEMICAL APPARATUS.

Plate I

Fig. 1.



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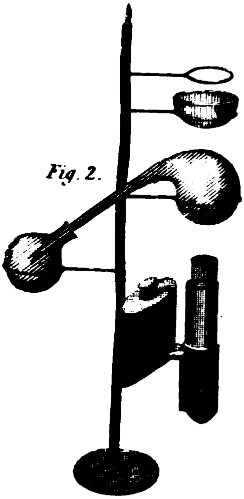

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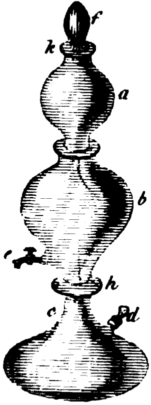
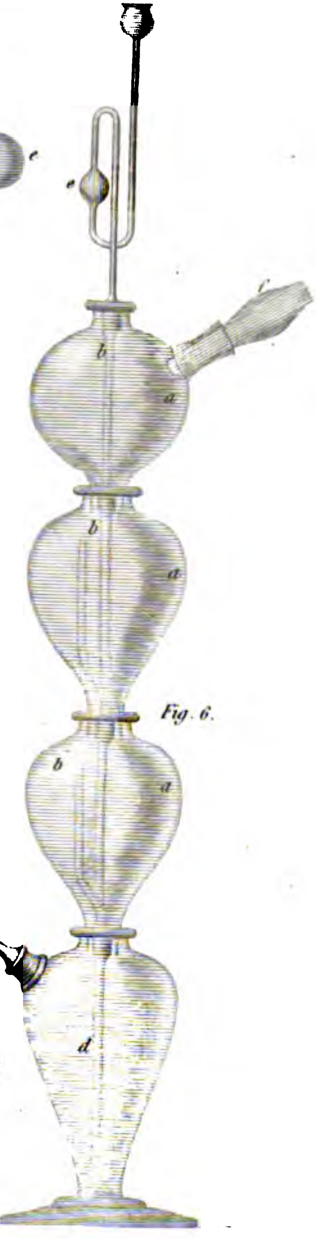


Fig. 6.



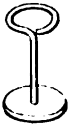


Fig. 3.

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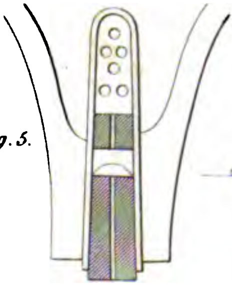
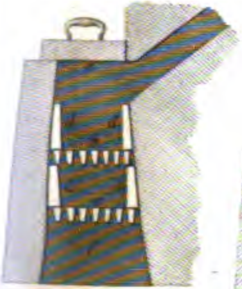


CHEMICAL APPARATUS.

Plate IV.



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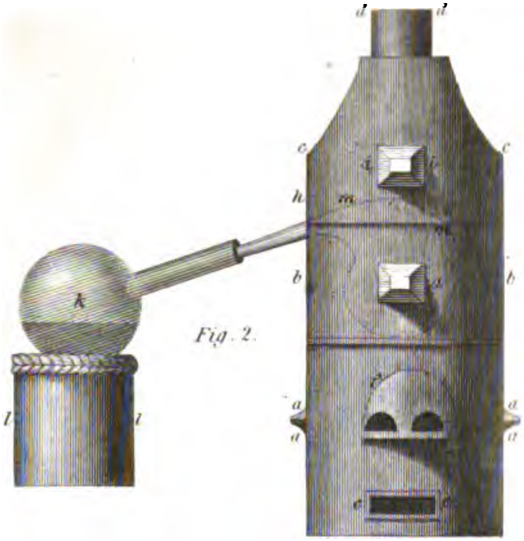

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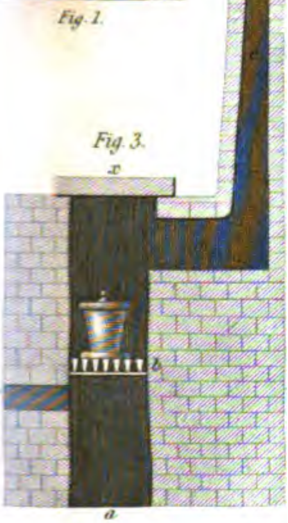

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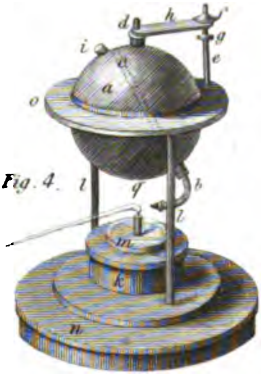

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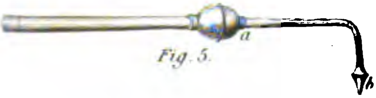

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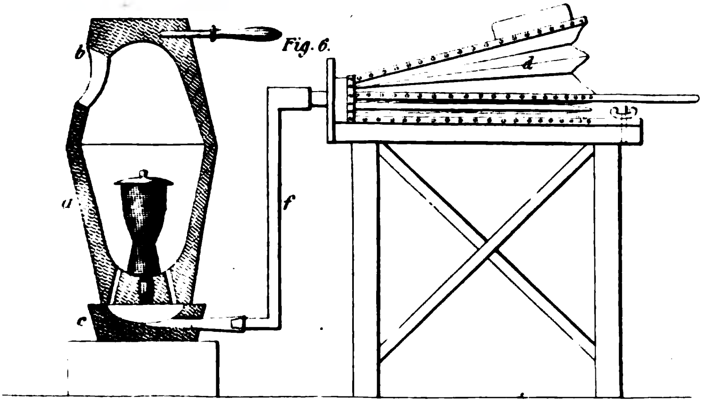

Fig. 6.

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Plate V.

CHEMICAL APPARATUS.

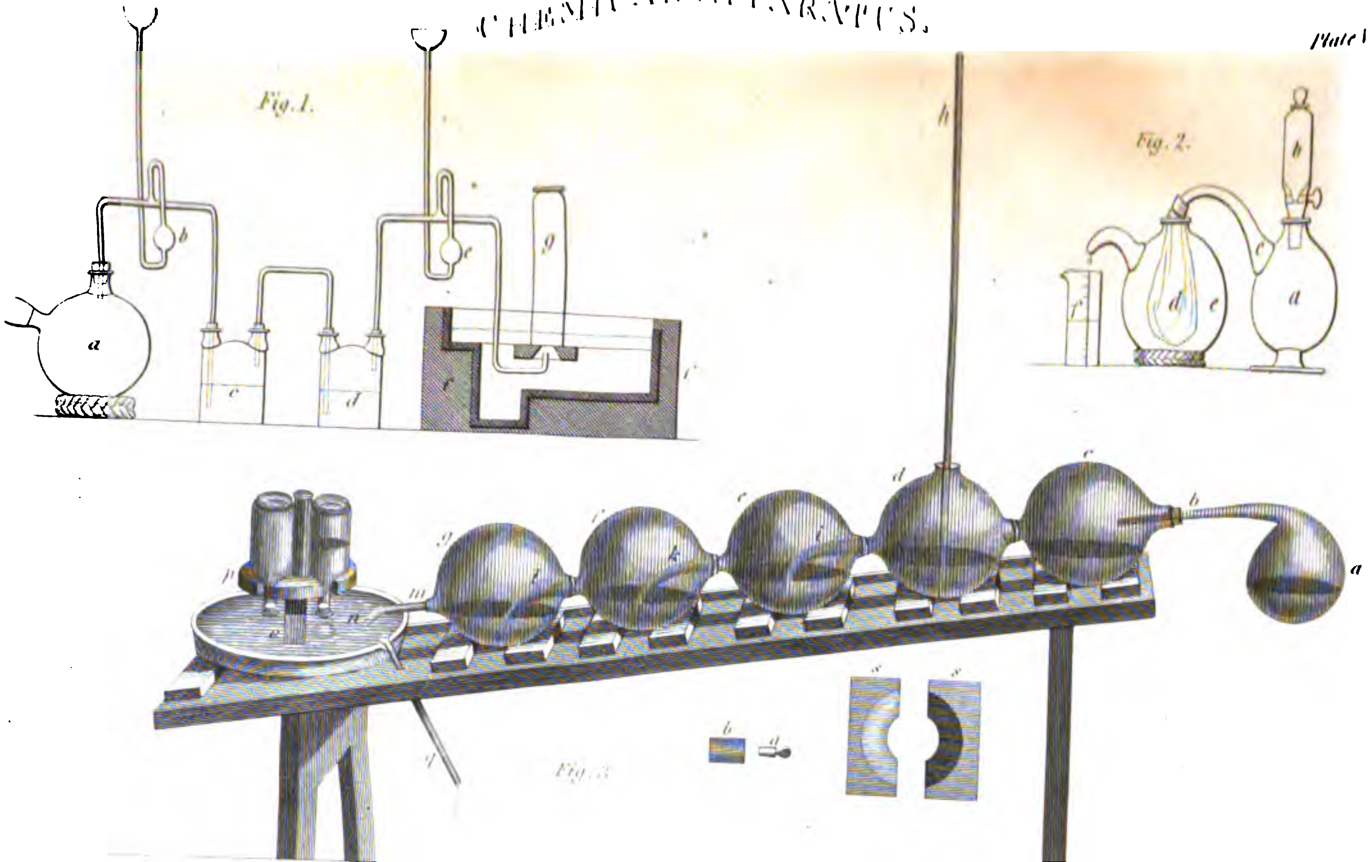
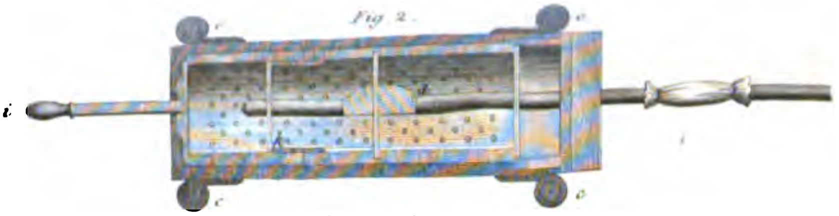


PLATE V.

Fig. 2.



Horizontal Section

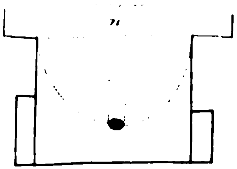
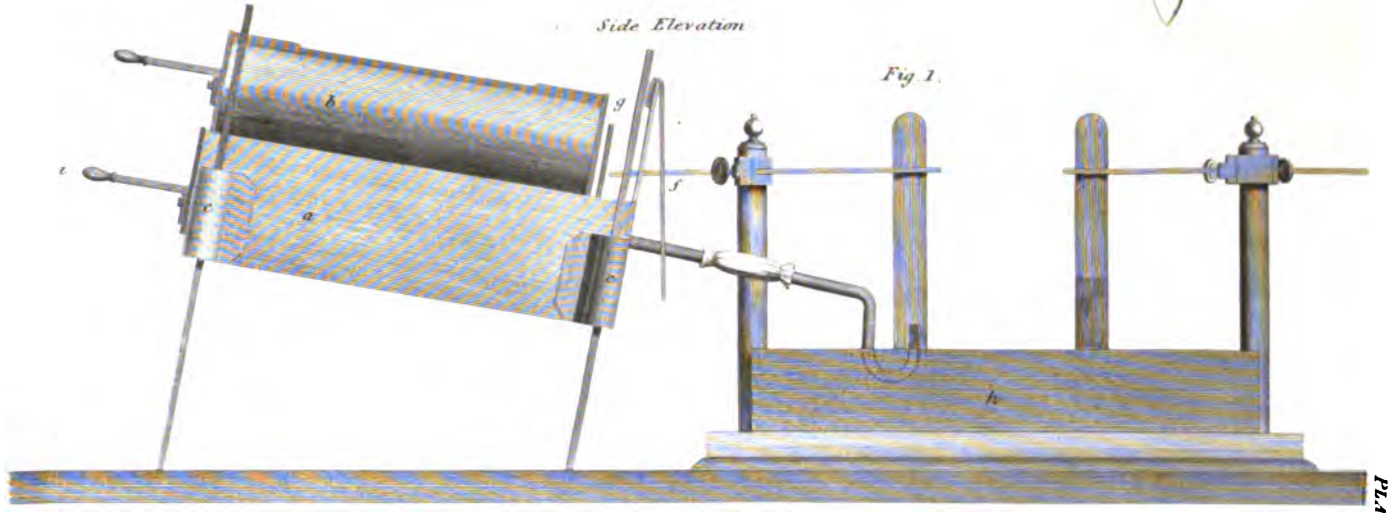


Fig. 4.

Side Elevation

Fig. 1.



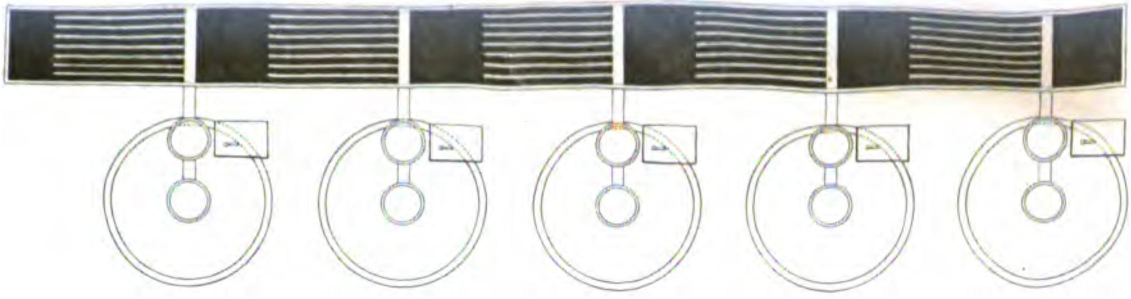
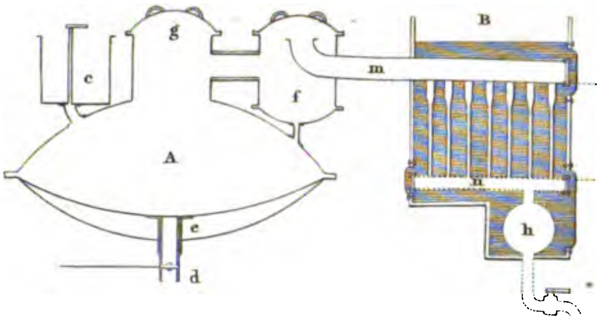


Fig. 1.



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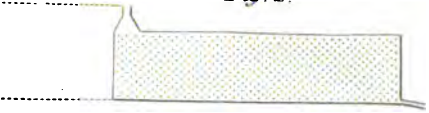
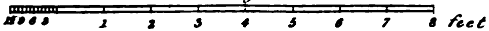


Scale to Fig. 1 & 2.



Scale to Fig. 3.

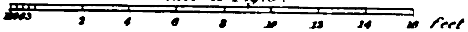


PLATE VII.

PL. I

Fig. 1.

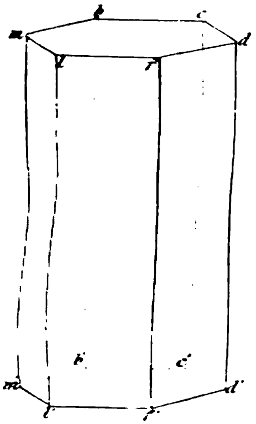


Fig. 2

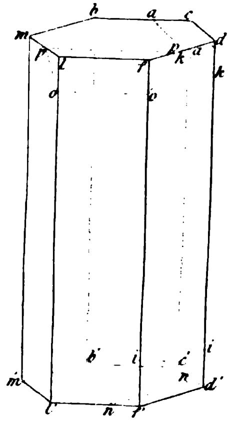


Fig. 3.

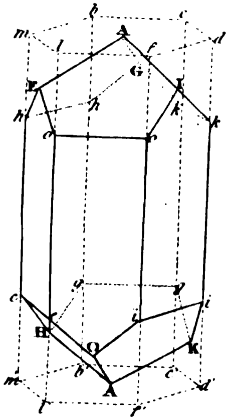


Fig. 4

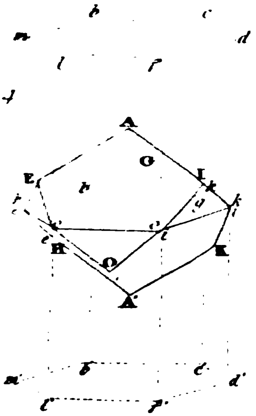
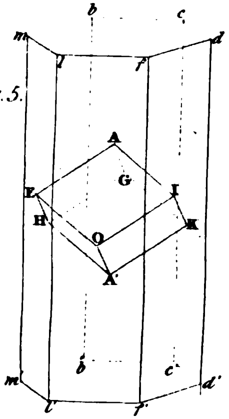


Fig. 5.



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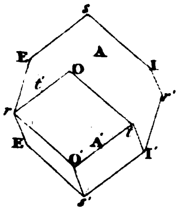

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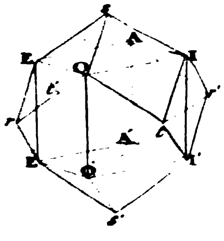


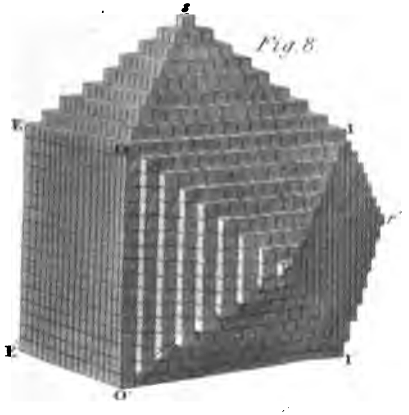
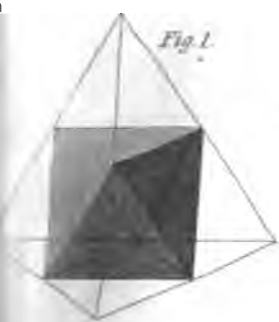


Fig. 8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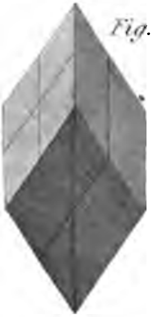
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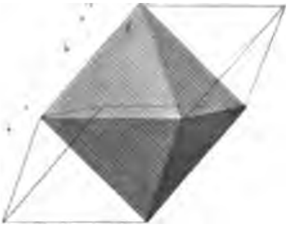
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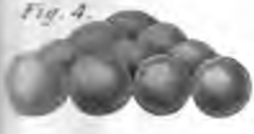
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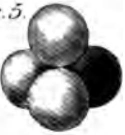
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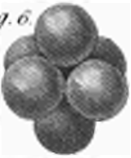
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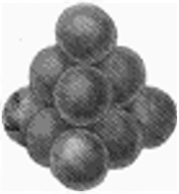
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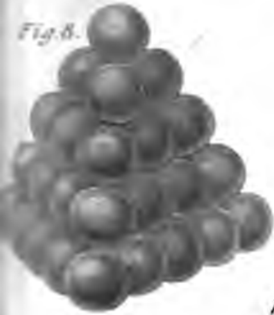
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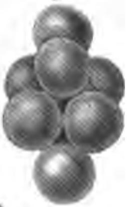
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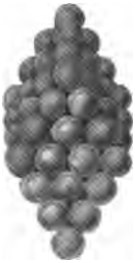
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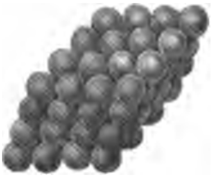
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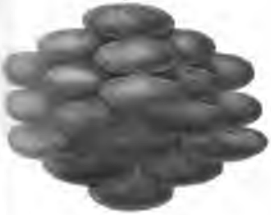
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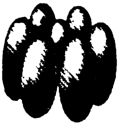
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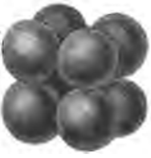
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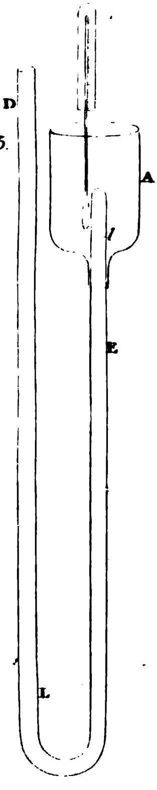
Fig. 15.

LIBRARY
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Dr J. L. Tanner
San Francisco 1851 May 15.

A
DICTIONARY
OF
CHEMISTRY.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA.

ABRAZITE, ZEAGONITE, or GISMONDINE. A mineral which occurs in semi-globular masses, and in octohedral crystals with a square base. Colour grayish-white, sometimes with a tinge of blue. Yields to the nail, but occasionally hard enough to scratch glass. Brittle. Fracture conchoidal. Translucent or transparent. Constituents: silica 41.4; lime 48.6; alumina 2.5; magnesia 1.5; oxide of iron 2.5. Reduced by acids to a jelly, without effervescence. Loses its lustre, and becomes friable before the blowpipe. It is found in the cavities of volcanic rocks, with calcareous spar, at Capo di Bove near Rome.—*Phillips' Mineralogy.*

ABSORBENT. An epithet introduced into chemistry by the physicians, to designate such earthy substances as seemed to check diarrhœa, by the mere absorption of the redundant liquids. In this sense it is obsolete and unfounded. The faculty of withdrawing moisture from the air is not confined to substances which unite with water in every proportion, as the strong acids, dry alkalis, alkaline earths, and deliquescent salts, but is possessed by insoluble and apparently inert bodies, in various degrees of force. Hence the term Absorbent merits a place in chemical nomenclature.

The substance whose absorbent power is to be examined, after thorough desiccation before a fire, is immediately transferred into a phial, furnished with a well ground stopper. When it is cooled, a portion of it is put into a large wide-mouthed bottle, where it is closely confined for some time. A delicate hygrometer being then introduced, indicates on its scale the dryness produced in the enclosed air, which should have been previously brought to the point of extreme humidity, by suspending a moistened rag within the bottle. The following table exhibits the results of experiments made by Professor Leslie:—

Alumina causes a dryness of	84 degrees.
Carbonate of magnesia,	75
Carbonate of lime,	70
Silica,	40
Carbonate of barytes,	32
Carbonate of strontites,	23
Pipe clay,	85
Greenstone, or trap in powder,	80
Shelly sea sand,	70
Clay indurated by torrefaction,	35
Clay strongly ignited,	8
Greenstone ignited,	23
Quartz do.	19
Decomposed greenstone,	86
Greenstone resolved into soil,	92
Garden mould,	95

The more a soil is comminuted by labour and vegetation, the greater is its absorbent power. This ingenious philosopher infers, that the fertility of soils depends chiefly on their disposition to imbibe moisture; and illustrates this idea by recent and by disintegrated lava. May not the finely divided state most penetrable by the delicate fibres of plants derive its superior power of acting on atmospherical vapour from the augmentation of its surface, or the multiplication of the points of contact?

In similar circumstances 100 gr. of the following organic substances absorb the following quantities of moisture: Ivory 7 gr. boxwood 14, down 16, wool 18, beech 28. Charcoal, and other porous solids of a fibrous texture, have the faculty of absorbing gases in a remarkable degree; for an account of M. de Saussure's excellent experiments on which subject, see the article Gas in this Dictionary.—*Leslie on Heat and Moisture.*

ABSORPTION. The passage of a gas, or vapour, into a liquid or solid substance; or of a liquid into the pores of a solid.

ACANTICONE. See PISTACITE.

ACERATES. The acer campestre, or common maple, yields a milky sweetish sap, containing a salt with basis of lime, possessed, according to Scherer, of peculiar properties. It is white, semitransparent, not altered by the air, and soluble in nearly 100 parts of cold, or 50 of boiling water.

ACERIC ACID. See ACID (ACERIC).

ACESCENT. Substances which become sour spontaneously, as vegetable and animal juices, or infusions. The suddenness with which this change is effected during a thunder storm, even in corked bottles, has not been accounted for. In morbid states of the stomach, also, it proceeds with astonishing rapidity. It is counteracted by bitters, antacids, and purgatives.

ACETATES. Salts formed by the combination of acetic acid with alkalis, earths, and metallic oxides. See ACID (ACETIC).

ACETIC ACID. See ACID (ACETIC).

ACETOMETER. An instrument for estimating the strength of vinegars. It is described under ACID (ACETIC).

ACETOUS. Of or belonging to vinegar. See ACID (ACETIC).

ACHMIT. A mineral first distinguished by Bergmeister Ström. It has a brownish black or reddish brown colour, is spotted, grayish-green in the fracture, externally of a glassy lustre, and in the transverse fracture glimmering. Translucent in small fragments. It has four cleavages, two of which are parallel to the sides of an oblique four-sided prism, and the other two, less obvious, are parallel to the truncations of the acute lateral edges. The fracture is small grained. Specific gravity 5.24. Hardness such as to scratch glass. It is likewise crystallized in oblique four-sided prisms, with truncated lateral edges, and very sharp four-sided terminal faces, the edges of which correspond with the lateral edges of the oblique prism. The sides are channelled in the direction of their length. According to Berzelius this mineral contains—silica 55.25, peroxide of iron 31.25, protoxide of manganese 1.08, lime 0.72, soda 10.40, oxide of titanium a trace. He considers it as a bisilicate of soda, combined with a bisilicate of iron.

ACHROMATIC. Telescopes formed of a combination of lenses, which in a great measure correct the optical aberration arising from the various colours of light, are called achromatic telescopes.

ACIDS. The most important class of chemical compounds. In the generalization of facts presented by Lavoisier and the associated French chemists, it was the leading doctrine that acids resulted from the union of a peculiar combustible base called the radical, with a common principle technically called oxygen, or the acidifier. This general position was founded chiefly on the phenomena exhibited in the formation and decomposition of sulphuric, carbonic, phosphoric, and nitric acids; and was extended by a plausible analogy to other acids whose radicals were unknown.

"I have already shown," says Lavoisier, "that phosphorus is changed by combustion into an extremely light, white, flaky matter. Its properties are likewise entirely altered by this transformation; from being insoluble in water, it becomes not only soluble, but so greedy of moisture as to attract the humidity of the air with astonishing rapidity. By this means it is converted into a liquid, considerably more dense, and of more specific gravity than water. In the state of phosphorus before combustion, it had scarcely any sensible taste; by its union with oxygen, it acquires an extremely sharp and sour taste; in a word, from one of the class of combustible bodies, it is changed into an incombustible substance, and becomes one of those bodies called acids.

"This property of a combustible substance, to be converted into an acid by the addition of oxygen, we shall presently find belongs to a great number of bodies. Wherefore strict logic requires that we should adopt a common term for indicating all these operations which produce analogous results. This is the true way to simplify the study of science, as it would be quite impossible to bear all its specific details in the memory if they were not classically arranged. For this reason we shall distinguish the conversion of phosphorus into an acid by its union with oxygen, and in general every combination of oxygen with a combustible substance, by the term *oxygenation*; from this I shall adopt the verb to oxygenate; and of consequence shall say, that in oxygenating phosphorus, we convert it into an acid.

"Sulphur also, in burning, absorbs oxygen gas; the resulting acid is considerably heavier than the sulphur burnt; its weight is equal to the sum of the weights of the sulphur which has been burnt, and of the oxygen absorbed; and, lastly, this acid is weighty, incombustible, and miscible with water in all proportions.

"I might multiply these experiments, and show, by a numerous succession of facts, that all acids are formed by the combustion of certain substances; but I am prevented from doing so in this place by the plan which I have laid down, of proceeding only from facts already ascertained to such as are unknown, and of drawing my examples only from circumstances already explained. In the mean time, however, the examples above cited may suffice for giving a clear and accurate conception of the manner in which acids are formed. By these it may be clearly seen that oxygen is an element common to them all, and which constitutes or produces their acidity; and that they differ from each other according to the several natures of the oxygenated or acidified substances. We must, therefore, in every acid carefully distinguish between the acidifiable base, which M. de Morveau calls the radical, and "the acidifying principle or oxygen." Elements, p. 115. "*Although* we have not yet been able either to compose or to decompound this acid of sea *salt*, we cannot have the smallest doubt that it, *like* all other acids, is composed by the union of oxygen with an acidifiable base. We have, therefore, called this unknown substance the muriatic base, or muriatic radical." P. 122. 5th Edition.

Berthollet's sound discrimination led him to maintain that Lavoisier had given too much latitude to the idea of oxygen being the *universal acidifying* principle. "In fact," says he, "it is carrying the limits of analogy too far to infer, that all acidity, even that of the muriatic, fluoric, and boracid acids, arises from oxygen, because it gives acidity to a great number of substances. Sulphuretted hydrogen, which really possesses the properties of an acid, proves directly that acidity is not in all cases owing to oxygen. There is no better foundation for concluding that hydrogen is the principle of alkalinity not only in the alkalis, properly so called, but also in magnesia, lime, strontian, and barytes, because ammonia appears to owe its alkalinity to hydrogen.

"*These* considerations prove that oxygen may be regarded as the most usual principle of acidity, but that this species of affinity for the alkalis may belong to substances which do not contain oxygen; that we must not, therefore, always infer, from the acidity of a substance, that it contains oxygen, although this may be an inducement to suspect its existence in it: still less should we conclude, because a substance contains oxygen, that it must have acid properties; on the contrary, the acidity of an oxygenated substance shows that the oxygen has only experienced an incomplete saturation in it, since its properties remain predominant."

Amid the just views which pervade the early part of this quotation from Berthollet, it is curious to remark the solecism with which it terminates. For after maintaining that acidity may exist independent of oxygen, and that the presence of oxygen does not necessarily constitute acidity, he concludes by considering acidity as the attribute of unsaturated oxygen.

This unwarrantable generalization of the French chemists concerning oxygen, which had succeeded Stahl's equally unwarrantable generalization of a common principle of combustibility in all combustible bodies, was first experimentally combated by Sir H. Davy, in a series of admirable dissertations published in the Philosophical Transactions.

His first train of experiments was instituted with the view of operating by voltaic electricity on muriatic and other acids freed from water. Substances which are now known by the names of chlorides of phosphorus and tin, but which he then supposed to contain dry muriatic acid, led him to imagine that intimately combined water was the real acidifying principle, since acid properties were immediately developed in the above substances by the addition of that fluid, though previously they exhibited no acid powers. In July 1810, however, he advanced those celebrated views concerning acidification, which, in the opinion of the best judges, display an unrivalled power of scientific research. The conclusions to which these led him were incompatible with the general hypothesis of Lavoisier. He demonstrated that oxymuriatic acid is, as far as our knowledge extends, a *simple* substance, which may be classed in the same order of natural bodies as oxygen gas, being determined like oxygen to the positive surface in voltaic combinations, and like oxygen combining with inflammable substances, producing heat and light. The combinations of oxymuriatic acid with inflammable bodies were shown to be analogous to oxides and acids in their properties and powers of combination, but to differ from them in being for the most part decomposable by water: and finally, that oxymuriatic acid has a stronger attraction for most inflammable bodies than oxygen. His preceding decomposition of the alkalis and earths having evinced the absurdity of that nomenclature which gives to the general and essential constituent of alkaline nature, the term oxygen or acidifier; his new discovery of the simplicity of oxymuriatic acid showed the theoretical system of chemical language to be equally vicious in another respect. Hence this philosopher most judiciously discarded the appellation oxymuriatic acid, and introduced in its place the name chlorine, which merely indicates an obvious and permanent character of the substance, its greenish-yellow colour. The more recent investigations of chemists on fluoric, hydriodic, and hydrocyanic acids, have brought powerful analogies in support of the chloridic theory, by showing that hydrogen alone can convert certain undecompounded bases into acids well characterized, without the aid of oxygen. Dr. Murray indeed endeavoured to revive and new-model the early opinion of Sir H. Davy, concerning the necessity of the presence of water, or its elements, to the constitution of acids. He conceived that many acids are ternary compounds of a radical with oxygen and hydrogen; but that the two latter ingredients do not necessarily exist in them in the state of water. Oil of vitriol, for instance, in this view, instead of consisting of 81.5 real acid, and 18.5 water in 100 parts, may be regarded as a compound of 32.6 sulphur + 65·2 oxygen, + 2.2 hydrogen. When it is saturated with an alkaline base, and exposed to heat, the hydrogen unites to its equivalent quantity of oxygen, to form water, which evaporates, and the remaining oxygen and the sulphur combine with the base. But when the acid is made to act on a metal, the oxygen partly unites to it, and hydrogen alone escapes.

"Nitric acid, in its highest state of concentration, is not a definite compound of real acid, with about a fourth of its weight of water, but a ternary compound of nitrogen, oxygen, and hydrogen. Phosphoric acid is a triple compound of phosphorus, oxygen, and hydrogen; and phosphorous acid is the proper binary compound of phosphorus and oxygen. The oxalic, tartaric, and other vegetable acids, are admitted to be ternary compounds of carbon, oxygen, and hydrogen; and are therefore in strict conformity to the doctrine now illustrated.

"A relation of the elements of bodies to acidity is thus discovered different from what has hitherto been proposed. When a series of compounds exist, which have certain common characteristic properties, and when these compounds all contain a common element, we conclude, with justice, that these properties are derived more peculiarly from the action of this element. On this ground Lavoisier inferred, by an ample induction, that oxygen is a principle of acidity. Berthollet brought into view the conclusion, that it is not exclusively so, from the examples of prussic acid and sulphuretted hydrogen. In the latter, acidity appeared to be produced by the action of hydrogen. The discovery by Gay Lussac, of the compound radical cyanogen, and its conversion into prussic acid by the addition of hydrogen, confirmed this conclusion; and the discovery of the relations of iodine still further established it. And now, if the preceding views are just, the system must be still further modified. While each of these conclusions is just to a certain extent, each of them requires to be limited in some of the cases to which they are applied; and while acidity is sometimes exclusively connected with oxygen, sometimes with hydrogen, the principle must also be admitted, that it is more frequently the result of their combined operation.

"There appears even sufficient reason to infer, that, from the united action of these elements, a higher degree of acidity is acquired than from the action of either alone. Sulphur affords a striking example of this. With hydrogen it forms a weak acid. With oxygen it also forms an acid, which, though of superior energy, still does not display much power. With hydrogen and oxygen it seems to receive the acidifying influence of both, and its acidity is proportionally exalted.

"Nitrogen, with hydrogen, forms a compound altogether destitute of acidity, and possessed even of qualities the reverse. With oxygen, in two definite proportions, it forms oxides; and it is doubtful if, in any proportion, it can establish with oxygen an insulated acid. But with oxygen and hydrogen in union it forms nitric acid, a compound more permanent, and of energetic action."

It is needless to give at more detail Dr. Murray's speculations, which, supposing them plausible in a theoretical point of view, seem barren in practice. It is sufficiently singular, that, in an attempt to avoid the transformations, which, on his notion of the chloridic theory, a little moisture operates on common salt, instantly changing it from chlorine and sodium into muriatic acid and soda, Dr. Murray should have actually multiplied, with one hand, the very difficulties which *he* had laboured, with the other, to remove.

He thinks it doubtful if nitrogen and oxygen can alone form an insulated acid. Hydrogen he conceives essential to its energetic action. What, we may ask then, exists in dry nitre, which contains no hydrogen? Is it nitric acid, or merely two of its elements, in want of a little water to furnish the requisite hydrogen? The same questions may be asked relative to the sulphate of potash. Since he conceives hydrogen necessary to communicate full force to sulphuric and nitric acids, the moment they lose their water they should lose their saturating power, and become incapable of retaining caustic potash in a neutral state. Out of this dilemma he may indeed try to escape, by saying, that moisture or hydrogen is equally essential to alkaline strength, and that therefore the same desiccation or de-hydrogenation which impairs the acid power, impairs also that of its alkaline antagonist. The result must evidently be, that in a saline hydrate or solution, we have the reciprocal attractions of a strong acid and alkali, while, in a dry salt, the attractive forces are those of relatively feeble bodies. On this hypothesis, the difference ought to be great between dry and moistened sulphate of potash. Carbonic acid he admits to be destitute of hydrogen; yet its saturating power is very conspicuous in neutralizing dry lime. Again, oxalic acid, by the last analysis of Berzelius, as well as my own, contains *no* hydrogen. It differs from the carbonic only in the proportion of its two constituents. And oxalic acid is appealed to by Dr. Murray as a proof of the superior acidity bestowed by hydrogen.

On what grounds he decides carbonic to be a feebler acid than oxalic, it is difficult to see. By Berthollet's test of acidity, the former is more energetic than the latter in the proportion of 100 to about 58; for these numbers are inversely as the quantity of each requisite to saturate a given base. If he be inclined to reject this rule, and appeal to the decomposition of the carbonates by oxalic acid, as a criterion of relative acid power, let us adduce his own commentary on the statical affinities of Berthollet, where he ascribes such changes, not to a superior attraction in the decomposing substance, but to the elastic tendency of that which is evolved. Ammonia separates magnesia from its muriatic solution at common temperatures; at the boiling heat of water, magnesia separates ammonia. Carbonate of ammonia, at temperatures under 230°, precipitates carbonate of lime from the muriate; at higher temperatures, the inverse decomposition takes place with the same ingredients. If the oxalic be a more energetic acid than the carbonic, or rank higher in the scale of acidity, then, on adding to a given weight of liquid muriate of lime a mixture of oxalate and carbonate of ammonia, each in equivalent quantity to the calcareous salt, oxalate of lime ought alone to be separated. It will be found, on the contrary, by the test of acetic acid, that as much carbonate of lime will precipitate as is sufficient to unsettle these speculations.

Finally, dry nitre, and dry sulphate of potash, are placed, by this supposition, in as mysterious a predicament as dry muriate of soda in the chloridic theory. Deprived of hydrogen, their acid and alkali are enfeebled or totally changed. With a little water, both instantly recruit their powers. In a word, the solid sulphuric acid of Nordhausen, and the *dry* potash of potassium, are alone sufficient *to* subvert this whole hypothesis of hydrogenation.

We shall introduce, under the head of alkali, some analogous speculations by Dr. Murray on the influence of the elements of water on that class of bodies. *Edin. Phil. Trans.* vol. viii. part 2d.

After these observations on the nature of acidity, we shall now state the general properties of the acids.

1. *The taste* of these bodies is for the most part sour, as their name denotes; and in the stronger species it is acrid and corrosive.

2. They generally combine with water in every proportion, with a condensation of volume and evolution of heat.

3. With a few exceptions they are volatilized or decomposed at a moderate heat.

4. They usually change the purple colours of vegetables to a bright red.

5. They unite in definite proportions with the alkalis, earths, and metallic oxides, and form the important class of salts. This may be reckoned their characteristic and indispensable property. The powers of the different acids were originally estimated by their relative causticity and sourness, afterwards by the scale of their attractive force towards any particular base, and next by the quantity of the base which they could respectively neutralize. But Berthollet proposed the converse of this last criterion as the measure of their powers. "The power with which they can exercise their acidity," he estimates "by the quantity of each of the acids which is required to produce the same effect, viz. to saturate a given quantity of the same alkali." It is therefore the capacity for saturation of each acid, which, in ascertaining its acidity, according to him, gives the comparative force of the affinity to which it is owing. Hence he infers, that the affinity of the different acids for an alkaline base, is in the inverse ratio of the ponderable quantity of each of them which is necessary to neutralize an equal quantity of the same alkaline base. An acid is, therefore, in this view, the more powerful, when an equal weight can saturate a greater quantity of an alkali. Hence, all those substances which can saturate the alkalis, and cause their properties to disappear, ought to be classed among the acids; in like manner, among the alkalis should be placed all those which, by their union, can saturate acidity. And the capacity for saturation being the measure of this property, it should be employed to form a scale of the comparative power of alkalis as well as that of acids.

However plausible, *a priori*, the opinion of this illustrious philosopher may be, that the smaller the quantity of an acid or alkali required to saturate a given quantity of its antagonist principle, the higher should it rank in the scale of power and affinity, it will not, however, accord with chemical phenomena.

100 parts of nitric acid are saturated by about 36½ of magnesia, and 52½ of lime. Hence, by Berthollet's rule, the powers of these earths ought to be inversely as their quantities, viz. $\frac{1}{36\frac{1}{2}}$ and $\frac{1}{52\frac{1}{2}}$; yet the very opposite effect takes place, for lime separates magnesia from nitric acid. And in the present example, the difference of effect cannot be imputed to the difference of force with which the substances tend to assume the solid state.

We have therefore at present no single acidifying principle, nor absolute criterion of the scale of power among the different acids; nor is the want of this of great importance. Experiment furnishes us with the order of decomposition of one acido-alkaline compound by another acid, whether alone, or aided by temperature; and this is all which practical chemistry seems to require.

Before entering on the particular acids, we shall here describe the general process by which M. Thenard has lately succeeded in communicating to many of them *apparently* a surcharge of oxygen, and thus producing a supposed new class of bodies, the oxygenized acids, which are, in reality, combinations of the ordinary acids with oxygenized water, or with the deutoxide of hydrogen. The first notice of these new compounds appeared in the *Ann. de Chimie et Physique*, viii. 306, for July 1818; since which time several additional communications of a very interesting nature have been made by the same celebrated chemist. He has likewise formed a compound of water with oxygen, in which the proportion of the latter principle is doubled, or 616 times its volume is added. The methods of oxygenizing the liquid acids and water agree in this, that deutoxide of barium is formed first of all, from which the above liquids, by a subsequent process, derive their oxygen. He prescribes the following precautions, without which success will be only partial:—

1. Nitrate of barytes should first be obtained perfectly pure, and above all, free from iron and manganese. The most certain means of procuring it is to dissolve the nitrate in water, to add to the solution a small excess of barytes water, to filter and crystallize. 2. The pure nitrate is to be decomposed by heat. This ought not to be done in a common earthenware retort, because it contains too much of the oxides of iron and manganese, but in a perfectly white porcelain retort. Four or five pounds of nitrate of barytes may be decomposed at once, and the process will require about three hours. The barytes thus procured will contain a considerable quantity of silex and alumina; but it will have only very minute traces of manganese and iron, a circumstance of essential importance. 3. The barytes divided by a knife into pieces as large as the end of the thumb, should then be placed in a luted tube of glass. This tube should be long, and large enough to contain from 2¼ to 3¼ lbs. It is to be surrounded with fire, and heated to dull redness, and then a current of dry oxygen gas is to be passed through it. However rapid the current, the gas is completely absorbed; so that when it passes by the small tube, which ought to terminate the larger one, it may be concluded that the deutoxide of barium is completed. It is, however, right to continue the current for seven or eight minutes more. Then the tube being nearly cold, the deutoxide, which is of a light grey colour, is taken out, and preserved in stoppered bottles. When this is moistened it falls to powder, without much increase of temperature. If in this state it be mixed with seven or eight times its weight of water, and a dilute acid be poured in, it dissolves gradually by agitation, without the evolution of any gas. The solution is neutral, or has no action on turnsole or turmeric. When we add to this solution the requisite quantity of sulphuric acid, a copious precipitate of barytes falls, and the filtered liquor is merely water, holding in solution the oxygenized acid, or deutoxide of hydrogen, combined with the acid itself.

The class of acids has been distributed into three orders, according as they are derived from the mineral, the vegetable, or the animal kingdom. But a more specific distribution is now requisite. They have also been arranged into those which have a single, and those which have a compound basis or radical. But this arrangement is not only vague, but liable in other respects to considerable objections. The chief advantage of a classification is to give general views to beginners in the study, by grouping together such substances as have analogous properties or composition. These objects, it is hoped, will be tolerably well attained by the following divisions and subdivisions.

Division 1st, Acids from inorganic nature, or which are procurable without having recourse to animal or vegetable products.

Division 2d, Acids elaborated by means of organization.

The first group is subdivided into three families: 1st, Oxygen acids; 2d, Hydrogen acids; 3d, Acids destitute of both these supposed acidifiers.

Family 1st.—Oxygen acids.

Section 1st, Non-metallic.

1. Boracic.
2. Bromic.
3. Carbonic.
4. Chloric.
5. Perchloric?
6. Chloro-Carbonic.
7. Iodous.
8. Nitrous.
9. Hyponitric.
10. Nitric.
11. Hyponitrous.
12. Iodic.
13. Iodo-Sulphuric.
14. Hypophosphorous.
15. Phosphorous.
16. Phosphatic.
17. Phosphoric.
18. Hyposulphurous.
19. Sulphurous.
20. Hyposulphuric.
21. Sulphuric.
22. Cyanic.

Section 2d, Oxygen acids.—*Metallic.*

1. Arsenic.
2. Arsenious.
3. Antimonious.
4. Antimonic.
5. Chromic.
6. Columbic.
7. Molybdic.
8. Molybdous.
9. Titanic.
10. Tungstic.

Family 2d.—Hydrogen acids.

1. Fluoric.
2. Hydriodic.
3. Hydrochloric, or Muriatic.
4. Ferroprussic.
5. Fluo-titanic.
6. Hydro-bromic.
7. Hydroselenic.
8. Hydroprussic, or Hydrocyanic.
9. Hydrosulphurous.
10. Hydrotellurous.
11. Hydroxanthic.
12. Sulphuroprussic.

Family 3d.—Acids without oxygen or hydrogen.

1. Chloriodic.
2. Chloroprussic, or Chlorocyanic.
3. Fluoboric.
4. Fluosilicic.

Division 2d.—Acids of organic origin.

1. Abietic.
2. Aceric.
3. Acetic.
4. Amniotic.

5. Benzoic.
6. Boletic.
7. Butyric.
8. Camphoric.
9. Capric, Caproic.
10. Caseic.
11. Cevadic.
12. Cholesteric.
13. Citric.
14. Croconic.
15. *Delphinic.*
16. Ellagic?
17. Formic.
18. Fulminic.
19. Fungic.
20. Gallic.
21. Hydroxanthic.
22. Igasuric.
23. Kinic.
24. Laccic.
25. Lactic.
26. *Lampic.*
27. Lithic or Uric.
28. Malic.
29. Meconic.
30. Menispermic?
31. Margaric.
32. Melassic?
33. Mellitic.
34. Moroxylic.
35. Mucic.
36. Nanceic?
37. Nitro-leucic.
38. Nitro-saccharic.
39. Oleic.
40. Oxalic.
41. Pectic.
42. Phocenic.
43. Pinic.
44. Purpuric.
45. Pyrocitric.
46. Pyrolithic.
47. Pyromalic.
48. Pyrotartaric.
49. Rosacic.
50. Saclactic.
51. Sebacic?
52. Suberic.
53. Succinic.
54. Sulpho-naphthalic.
55. Sulphovinic?
56. Tartaric.

The acids of this last division are all decomposable at a red heat, and afford generally carbon, hydrogen, oxygen, and in some few cases also nitrogen. The mellitic is found like amber in wood coal, and, like it, is undoubtedly of organic origin. We shall treat of them all in alphabetical order, only joining those acids together which graduate, so to speak, into each other, as hyposulphurous, sulphurous, hyposulphuric, and sulphuric.

ACID (ABIETIC). A substance, crystallizing in square plates, soluble in alcohol, and capable of forming salts with the alkalis, extracted from the resin of the *Pinus Abies* by M. Baup of Lausanne.

ACID (ACERIC). A peculiar acid said to exist in the juice of the maple. It is decomposed by heat, like the other vegetable acids.

ACID (ACETIC). The same acid which, in a *very dilute* and somewhat impure state, is called vinegar.

This acid is found combined with potash in the juices of a great many plants; particularly the sambucus nigra, phœnix dactilifera, galium verum, and rhus typhinus. Sweat, urine, and even fresh milk contain it. It is frequently generated in the stomachs of dyspeptic patients. Almost all dry vegetable substances, and some animal, subjected in close vessels to a red heat, yield it copiously. It is the result likewise of a spontaneous fermentation, to which liquid vegetable, and animal matters are liable. Strong acids, as the sulphuric and nitric, develop the acetic by their action on vegetables. It was long supposed on the authority of Boerhaave, that the fermentation which forms vinegar is uniformly preceded by the vinous. This is a mistake. Cabbages sour in water, making sour crout; starch, in starch-makers' sour waters; and dough itself, without any previous production of wine.

The varieties of acetic acids known in commerce are four: 1st, Wine vinegar; 2d, Malt vinegar; 3d, Sugar vinegar; 4th, Wood vinegar. We shall describe first the mode of making these commercial articles, and then that of extracting the absolute acetic acid of the chemist, either from these vinegars, or directly from chemical compounds, of which it is a constituent.

The following is the plan of making vinegar at present practised in Paris. The wine destined for vinegar is mixed in a large tun with a quantity of wine lees, and the whole being transferred into cloth-sacks, placed within a large iron-bound vat, the liquid matter is extruded through the sacks by superincumbent pressure. What passes through is put into large casks, set upright, having a small aperture in their top. In these it is exposed to the heat of the sun in summer, or to that of a stove in winter. Fermentation supervenes in a few days. If the heat should then rise too high, it is lowered by cool air, and the addition of fresh wine. In the skilful regulation of the fermentative temperature consists the art of making good wine vinegar. In summer, the process is generally completed in a fortnight: in winter, double the time is requisite. The vinegar is then run off into barrels, which contain several chips of birch-wood. In about a fortnight it is found to be clarified, and is then fit for the market. It must be kept in close casks.

The manufacturers at Orleans prefer wine of a year old for making vinegar. But if by age the wine has lost its extractive matter, it does not readily undergo the acetous fermentation. In this case, acetification, as the French term the process, may be determined, by adding slips of vines, bunches of grapes, or green woods. It has been asserted, that alcohol, added to fermentable liquor, does not increase the product of vinegar. But this is a mistake. Stahl observed long ago, that if we moisten roses or lilies with alcohol, and place them in vessels in which they are stirred from time to time, vinegar will be formed. He also informs us, if after abstracting the citric acid from lemon juice by crabs' eyes (carbonate of lime), we add a little alcohol to the supernatant liquid, and place the mixture in a proper temperature, vinegar will be formed.

Chaptal says, that two pounds of weak spirits, sp. gr. 0.985, mixed with 300 grains of beer yeast, and a little starch water produced extremely strong vinegar. The acid was developed on the 5th day. The same quantity of starch and yeast, without the spirit, fermented more slowly, and yielded a weaker vinegar. A slight motion is found to favour the formation of vinegar, and to endanger its decomposition after it is made. Chaptal ascribes to agitation the operation of thunder; though it is well known, that when the atmosphere is highly electrified, beer is apt to become suddenly sour, without the concussion of a thunder-storm. In cellars exposed to the vibrations occasioned by the rattling of carriages, vinegar does not keep well. The lees, which had been deposited by means of isinglass and repose, are thus jumbled into the liquor, and make the fermentation recommence.

Almost all the vinegar of the north of France being prepared at Orleans, the manufacture of that place has acquired such celebrity, as to render their process worthy of a separate consideration.

The Orleans casks contain nearly 400 pints of wine. Those which have been already used are preferred. They are placed in three rows, one over another, and in the top have an aperture of two inches diameter, kept always open. The wine for acetification is kept in adjoining casks, containing beech shavings, to which the lees adhere. The wine thus clarified is drawn off to make vinegar. One hundred pints of good vinegar, boiling hot, are first poured into each cask, and left there for eight days. Ten pints of wine are mixed in, every eight days, till the vessels are full. The vinegar is allowed to remain in this state fifteen days, before it is exposed to sale.

The *used* casks, called *mothers*, are never emptied more than half, but are successively filled again, to acetify new portions of wine. In order to judge if the *mother* works, the vinegar makers plunge a spatula into the liquid; and according to the quantity of froth which the spatula shows, they add more or less wine. In summer, the atmospheric heat is sufficient. In winter, stoves heated to about 75° Fahr. maintain the requisite temperature in the manufactory.

In some country districts, the people keep in a place where the temperature is mild and equable, *a vinegar cask*, into which they pour such wine as they wish to acetify; and it is always preserved full, by replacing the vinegar drawn off, by new wine. To establish this household manufacture, it is only necessary to buy at first a small cask of good vinegar.

At Gand a vinegar from beer is made, in which the following proportions of grain are found to be most advantageous:—

1880	Paris lbs. malted barley.	
700	—	wheat.
580	—	buck wheat.

These grains are ground, mixed, and boiled, along with twenty-seven casks-full of river water, for three hours. Eighteen casks of good beer for vinegar are obtained. By a subsequent decoction, more fermentable liquid is extracted, which is mixed with the former. The whole brewing yields 3000 English quarts.

In this country, vinegar is usually made from malt. By mashing with hot water, 100 gallons of wort are extracted in less than two hours from 1 boll of malt. When the liquor has fallen to the temperature of 75° Fahr. 4 gallons of the barm of beer are added. After thirty-six hours it is racked off into casks, which are laid on their sides, and exposed, with their bung-holes loosely covered, to the influence of the sun in summer; but in winter they are arranged in a stove-room. In three months this vinegar is ready for the manufacture of sugar of lead. To make vinegar for domestic use, however, the process is somewhat different. The above liquor is racked off into casks placed upright, having a false cover pierced with holes fixed at about a foot from their bottom. On this a considerable quantity of *rape*, or the refuse from the makers of British wine, or otherwise a quantity of low priced raisins, is laid. The liquor is turned into another barrel every twenty-four hours, in which time it has begun to grow warm. Sometimes, indeed, the vinegar is fully fermented, as above, without the rape, which is added towards the end, to communicate flavour. Two large casks are in this case worked together, as is described long ago by Boerhaave, as follows:—

"Take two large wooden vats, or hogsheads, and in each of these place a wooden grate or hurdle, at the distance of a foot from the bottom. Set the vessel upright, and on the grate place a moderately close layer of green twigs, or fresh cuttings of the vine. Then fill up the vessel with the footstalks of grapes, commonly called the rape, to the top of the vessel, which must be left quite open.

"Having thus prepared the two vessels, pour into them the wine to be converted into vinegar, so as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half filled vessel with liquor from that which is quite full, and which will now in its turn only be left half full. Four-and-twenty hours afterwards repeat the same operation, and thus go on, keeping the vessels alternately full and half full during twenty-four hours till the vinegar be made. On the second or third day there will arise in the half filled vessel, a fermentative motion, accompanied with a sensible heat, which will gradually increase from day to day. On the contrary, the fermenting motion is almost imperceptible in the full vessel; and as the two vessels are alternately full and half full, the fermentation is by this means in some measure interrupted, and is only renewed every other day in each vessel.

"When this motion appears to have entirely ceased, even in the half filled vessel, it is a sign that the fermentation is finished; and therefore the vinegar is then to be put into casks close stopped, and kept in a cool place.

"A greater or less degree of warmth accelerates or checks this, as well as the spirituous fermentation. In France it is finished in about fifteen days, during the summer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Reaumur's thermometer (88¼° Fahr.), the half filled vessel must be filled up every twelve hours; because, if the fermentation be not so checked in that time, it will become violent, and the liquor will be so heated, that many of the spirituous parts, on which the strength of the vinegar depends, will be dissipated, so that nothing will remain after the fermentation but a vapid liquor, sour indeed, but effete. The better to prevent the dissipation of the spirituous parts, it is a proper and usual precaution to close the mouth of the half filled vessel, in which the liquor ferments, with a cover made of oak wood. As to the full vessel, it is always left open, that the air may act freely on the liquor it contains; for it is not liable to the same inconveniences, because it ferments very slowly."

Good vinegar may be made from a weak syrup, consisting of 18 oz. of sugar to every gallon of water. The yeast and rape are to be here used as above described. Whenever the vinegar (from the taste and flavour) is considered to be complete, it ought to be decanted into tight barrels or bottles, and well secured from access of air. A momentary ebullition before it is bottled is found favourable to its preservation. In a large manufactory of malt vinegar, a considerable revenue is derived from the sale of yeast to the bakers.

Vinegar obtained by the preceding methods has more or less of a brown colour, and a peculiar but rather grateful smell. By distillation in glass vessels the colouring matter, which resides in a mucilage, is separated, but the fragrant odour is generally replaced by an *empyreumatic* one. The best French wine vinegars, and also some from malt, contain a little alcohol, which comes over early with the watery part, and renders the first product of distillation scarcely denser, sometimes even less dense, than water. It is accordingly rejected. Towards the end of the distillation the empyreuma increases. Hence only the intermediate portions are retained as distilled vinegar. Its specific gravity varies from 1.005 to 1.015, while that of common vinegar of equal strength varies from 1.010 to 1.025.

A crude vinegar has been long prepared for the calico printers, by subjecting wood in iron retorts to a strong red heat. The following arrangement of apparatus has been found to answer well. A series of cast-iron cylinders, about 4 feet diameter, and 6 feet long, are built horizontally in brick-work, so that the flame of one furnace may play round about two cylinders. Both ends project a little from the brick-work. One of them has a disc of cast-iron well fitted and firmly bolted to it, from the centre of which disc an iron tube about 6 inches diameter proceeds, and enters at a right angle the *main* tube of refrigeration. The diameter of this tube may be from 9 to 14 inches, according to the number of cylinders. The other end of the cylinder is called the mouth of the retort. This is closed by a disc of iron, smeared round its edge with clay-lute, and secured in its place by wedges. The charge of wood for such a cylinder is about 8 cwt. The hard woods, oak, ash, birch, and beech, are alone used. Fir does not answer. The heat is kept up during the day-time, and the furnace is allowed to cool during the night. Next morning the door is opened, the charcoal removed, and a new charge of wood is introduced. The average product of crude vinegar called pyrolignous acid is 35 gallons. It is much contaminated with tar; is of a deep brown colour; and has a sp. gr. of 1.025. Its total weight is therefore about 300 lbs. But the residuary charcoal is found to weigh no more than one-fifth of the wood employed. Hence nearly one-half of the ponderable matter of the wood is dissipated in incondensable gases. Count Rumford states, that the charcoal is equal in weight to more than four-tenths of the wood from which it is made. The Count's error seems to have arisen from the slight heat of an oven to which his wood was exposed in a glass cylinder. The result now given is the experience of an eminent manufacturing chemist at Glasgow. The crude pyrolignous acid is rectified by a second distillation in a copper still, in the body of which about 20 gallons of viscid tarry matter are left from every 100. It has now become a transparent brown vinegar, having a considerable empyreumatic smell, and a sp. gr. of 1.013. Its acid powers are superior to those of the best household vinegar, in the proportion of 3 to 2. By redistillation, saturation with quicklime, evaporation of the liquid acetate to dryness, and gentle torrefaction, the empyreumatic matter is so completely dissipated, that on decomposing the calcareous salt by sulphuric acid, a pure, perfectly colourless, and grateful vinegar rises in distillation. Its strength will be proportional to the concentration of the decomposing acid.

The acetic acid of the chemist may be prepared in the following modes: 1st, Two parts of fused acetate of potash with one of the strongest oil of vitriol yield, by slow distillation from a glass retort into a refrigerated receiver, concentrated acetic acid. A small portion of sulphurous acid, which contaminates it, may be removed by redistillation, from a little acetate of lead. 2d, Or

4 parts of good sugar of lead, with 1 part of sulphuric acid treated in the same way, afford a slightly weaker acetic acid. 3d, Gently calcined sulphate of iron, or green vitriol, mixed with sugar of lead in the proportion of 1 of the former to 2½ of the latter, and carefully distilled from a porcelain retort into a cooled receiver, may be also considered a good economical process. Or without distillation, if 100 parts of well dried acetate of lime be cautiously added to 60 parts of strong sulphuric acid, diluted with 5 parts of water, and digested for 24 hours, and strained, a good acetic acid, sufficiently strong for every ordinary purpose, will be obtained.

The distillation of acetate of copper or of lead *per se*, has also been employed for obtaining strong acid. Here, however, the product is mixed with a portion of the fragrant pyro-acetic spirit, which it is troublesome to get rid of. Undoubtedly the best process for the strong acid is that first described, and the cheapest the second or third. When of the utmost possible strength its sp. gravity is 1.062. At the temperature of 50° F. it assumes the solid form, crystallizing in oblong rhomboidal plates. It has an extremely pungent odour, affecting the nostrils and eyes even painfully, when its vapour is incautiously snuffed up. Its taste is eminently acid and acrid. It excoriates and inflames the skin.

The purified wood vinegar, which is used for pickles and culinary purposes, has commonly a specific gravity of about 1.009; when it is equivalent in acid strength to good wine or malt vinegar of 1.014. It contains about $\frac{1}{20}$ of its weight of absolute acetic acid, and $\frac{19}{20}$ of water. An excise duty of 4d. is levied on every gallon of vinegar of the above strength. This, however, is not estimated directly by its sp. gr. but by the sp. gr. which results from its saturation with quicklime. The decimal number of the sp. gr. of the calcareous acetate is nearly double that of the pure wood vinegar. Thus 1.009 in vinegar, becomes 1.018 in liquid acetate. But the vinegar of fermentation = 1.014 will become only 1.023 in acetate, from which, if 0.005 be subtracted for mucilage or extractive, the remainder will agree with the density of the acetate from wood. A glass hydrometer of Fahrenheit's construction is used for finding the specific gravities. It consists of a globe about 3 inches diameter, having a little ballast ball drawn out beneath, and a stem above of about 3 inches long, containing a slip of paper with a transverse line in the middle, and surmounted with a little cup for receiving weights or poises. The experiments on which this instrument, called an *Acetometer*, is constructed, have been detailed in the sixth volume of the Journal of Science. They do not differ essentially from those of Mollerat. The following points were determined by this chemist. The acid of sp. gr. 1.063 requires 2½ times its weight of crystallized subcarbonate of soda for saturation, whence M. Thenard regards it as a compound of 11 of water, and 89 of real acid in the 100 parts. Combined with water in the proportion of 100 to 112.2, it does not change its density, but it then remains liquid several degrees below the freezing point of water. By diluting it with a smaller quantity of water, its sp. gr. augments, a circumstance peculiar to this acid. It is 1.079, or at its *maximum*, when the water forms one-third of the weight of the acid.—*Ann. de Chimie*, tom. 66.

The following table is given by Messrs. Taylor, as the basis of their acetometer:—

Revenue proof acid, called by the manufacturer No. 24.

sp. gr. 1.0085	contains real acid in 100;	5
1.0170	- - - -	10
1.0257	- - - -	15
1.0320	- - - -	20
1.0470	- - - -	30
1.0580	- - - -	40

An acetic acid of very considerable strength may also be prepared by saturating perfectly dry charcoal with common vinegar, and then distilling. The water easily comes off, and is separated at first; but a stronger heat is required to expel the acid. Or by exposing vinegar to very cold air, or to freezing mixtures, its water separates in the state of ice, the interstices of which are occupied by a strong acetic acid, which may be procured by draining. The acetic acid or radical vinegar of the apothecaries, in which they dissolve a little camphor, or fragrant essential oil, has a specific gravity of about 1.070. It contains fully 1 part of water to 2 of the crystallized acid. The pungent smelling salt consists of sulphate of potash moistened with that acid. Acetic acid acts on tin, iron, zinc, copper, and nickel; and it combines readily with the oxides of many other metals, by mixing a solution of their sulphates with that of an acetate of lead.

This acid, as it exists in the acetates of barytes and of lead, has been analyzed by MM. Gay Lussac and Thenard, and also by Berzelius.

Gay Lussac found 50.224 carbon, 5.629 hydrogen, and 44.147 oxygen; or, in other terms, 50.224 carbon, 46.911 of water, or its elementary constituents, and 2.863 oxygen in excess.

Berzelius,—46.83 carb. 6.33 hydr. and 46.82 oxygen in the hundred parts.

Their methods are described under VEGETABLE (ANALYSIS). By saturating known weights of bases with acetic acid, and ascertaining the quantity of acetates obtained after cautious evaporation to dryness, Berzelius obtained with lime (3.56) 6.5 for the prime equivalent of acetic acid, and with yellow oxide of lead 6.432. Recent researches, which will be published in a detailed form, induce me to fix the prime of acetic acid at 7.0.

Acetic acid dissolves resins, gum resins, camphor, and essential oils. Its odour is employed in medicine to relieve nervous headache, fainting fits, or sickness occasioned by crowded rooms. In a slightly dilute state, its application has been found to check hemorrhagy from the nostrils. Its anticontagious powers are now little trusted to. It is very largely used in calico printing. Moderately rectified pyroligneous acid has been recommended for the preservation of animal food; but the empyreumatic taint it communicates to bodies immersed in it, is not quite removed by their subsequent ebullition in water. See ACID (PYROLIGNOUS.)

Acetic acid and common vinegar are sometimes fraudulently mixed with sulphuric acid to give them strength. This adulteration may be detected by the addition of a little chalk, short of their saturation. With pure vinegar the calcareous base forms a limpid solution, but with sulphuric acid a white insoluble gypsum. Muriate of barytes is a still nicer test. British fermented vinegars are allowed by law to contain a little sulphuric acid, but the quantity is frequently exceeded. Copper is discovered in vinegars by supersaturating them with ammonia, when a fine blue colour is produced; and lead by sulphate of soda, hydrosulphurets, and sulphuretted hydrogen. None of these should produce any change on genuine vinegar. See LEAD.

Acetic acid dissolves deutoxide of barium without effervescence. By precipitating the barytes with sulphuric acid, there remains an oxygenized acid, which, being saturated with potash, and heated, allows a great quantity of oxygen gas to escape. There is disengaged at the same time a notable quantity of carbonic acid gas. This shows that the oxygen, when assisted by heat, unites in part with the carbon, and doubtless likewise with the hydrogen of the acid. It is in fact acetic deutoxide of hydrogen.

Salts consisting of the several bases, united in definite proportions to acetic acid, are called acetates. They are characterized by the pungent smell of vinegar, which they exhale on the affusion of sulphuric acid; and by their yielding on distillation in a moderate red heat a very light, odorous, and combustible liquid called pyro-acetic (SPIRIT); which see. They are all soluble in water; many of them so much so as to be uncrystallizable. About 30 different acetates have been formed, of which only a very few have been applied to the uses of life.

The acetic acid unites with all the alkalis and most of the earths, and with these bases it forms compounds, some of which are crystallizable. The salts it forms are distinguished by their great solubility; their decomposition by fire, which carbonizes them; the spontaneous alteration of their solution; and their decomposition by a great number of acids, which extricate from them the acetic acid in a concentrated state. It unites likewise with most of the metallic oxides.

With barytes, the saline mass, by spontaneous evaporation, crystallizes in fine transparent prismatic needles, of a bitterish acid taste, which do not deliquesce when exposed to the air, but rather effloresce.

With potash this acid unites, and forms a deliquescent salt scarcely crystallizable, called formerly foliated earth of tartar, and regenerated tartar. The solution of this salt, even in closely stopped vessels, is spontaneously decomposed.

With soda it forms a crystallizable salt, which does not deliquesce.

The salt formed by dissolving chalk or other calcareous earth in distilled vinegar, has a sharp bitter taste, and appears in the form of silky crystals.

The acetate of strontian has a sweet taste, is very soluble, and is easily decomposed by a strong heat.

The salt formed by uniting vinegar with ammonia, anciently called spirit of Mindererus, is generally in a liquid state, and is commonly believed not to be crystallizable. It nevertheless may be reduced into the form of small needle-shaped crystals, when this liquor is evaporated to the consistence of a syrup.

With magnesia the acetic acid forms a viscid saline mass, which does not shoot into crystals, but remains deliquescent, has a taste sweetish at first, and afterwards bitter, and is soluble in spirit of wine.

Glucine is readily dissolved by acetic acid. This solution, as Vauquelin informs us, does not crystallize; but is reduced by evaporation to a gummy substance, which slowly becomes dry and brittle; retaining a kind of ductility for a long time. It has a saccharine and pretty strongly astringent taste, in which that of vinegar however is distinguishable.

Yttria dissolves readily in acetic acid, and the solution yields by evaporation crystals of acetate of yttria. These have commonly the form of thick six-sided plates, and are not altered by exposure to the air.

Acetate of alumina is commonly made by adding gradually to a boiling solution of alum in water a solution of acetate of lead, till no further precipitate ensues. The sulphate of lead having subsided, decant the supernatant liquor, evaporate, and the acetate of alumina may be obtained in small needle-shaped crystals, having a strong styptic and acetous taste. This salt is of great use in dyeing and calico-printing. See ALUMINA.

Acetate of zircone may be formed by pouring acetic acid on newly precipated zircone. It has an astringent taste. It does not crystallize; but when evaporated to dryness, forms a powder, which does not attract moisture from the air. It is very soluble both in water and alcohol; and is not so easily decomposed by heat as nitrate of zircone.

Concerning the action of vinegar on alcohol, see ETHER.

M. Vauquelin has found that acetic acid may be combined with volatile oils. See OILS (VOLATILE.)

See SPIRIT (PYRO-ACETIC).

Vinegar dissolves the true gums, and partly the gum resins, by means of digestion.

See SALT, for a tabular view of the constitution of the ACETATES.

ACID (AMNIOTIC). On evaporating the liquor amnii of the cow to one-fourth, Vauquelin and Buniva found, that crystals form in it by cooling. These crystals when washed with a little water, are white and shining, slightly acid to the taste, redden litmus paper, and are a little more soluble in hot than cold water. With the alkalis this acid forms very soluble salts, but it does not decompose the carbonate without the assistance of heat.

Dr. Prout could not find this acid in the amniotic liquor of the cow, though he sought for it with much pains. Hence its existence is questionable.

ACIDS (ANTIMONIC AND ANTIMONIOUS). See ANTIMONY.

ACID (ARSENIC). We are indebted to the illustrious Scheele for the discovery of this acid, though Macquer had before noticed its combinations. It may be obtained by various methods. If six parts of nitric acid be poured on one of the concrete arsenious acid, or white arsenic of the shops, in the pneumato-chemical apparatus, and heat be applied, nitrous gas will be evolved, and a white concrete substance, differing in its properties from the arsenious acid, will remain in the retort. This is the arsenic acid. It may equally be procured by means of aqueous chlorine, or by heating concentrated nitric acid with twice its weight of the solution of the arsenious acid in muriatic acid. The concrete acid should be exposed to a dull red heat for a few minutes. In either case an acid is obtained, that does not crystallize, but attracts the moisture of the air, has a sharp caustic taste, reddens blue vegetable colours, is fixed in the fire, and of the specific gravity of 3.391.

If the arsenic acid be exposed to a red heat in a glass retort, it melts and becomes transparent, but assumes a milky hue on cooling. If the heat be increased, so that the retort begins to melt, the acid boils, and sublimes into the neck of the retort. If a covered crucible be used instead of a glass retort, and a violent heat applied, the acid boils strongly, and in a quarter of an hour begins to emit fumes. These, on being received in a glass bell, are found to be arsenious acid; and a small quantity of a transparent glass, difficult to fuse, will be found lining the sides of the crucible. This is arseniate of alumina.

Combustible substances decompose this acid, and eliminate metallic arsenic.

If pure arsenic acid be diluted with a small quantity of water, and hydrogen gas, as it is evolved by the action of sulphuric acid on iron, be received into this transparent solution, the liquor grows turbid, and a blackish precipitate is formed, which being well washed with distilled water, exhibits all the phenomena of arsenic. Sometimes, too, a blackish-grey oxide of arsenic is found in this process.

If sulphuretted hydrogen gas be employed instead of simple hydrogen gas, water and a sulphuret of arsenic are obtained.

With phosphorus, phosphoric acid is obtained, and a phosphuret of arsenic, which sublimes.

According to Lagrange, two parts of water are sufficient to dissolve one of arsenic acid. It cannot be crystallized by any means; but on evaporation, assumes a thick honey-like consistence.

Arsenic acid combines with the earthy and alkaline bases, and forms salts very different from those furnished by the arsenious acid.

All these arseniates are decomposable by charcoal, which separates arsenic from them by means of heat.

Berzelius, from the result of accurate experiments on the arseniates of lead and barytes, infers the prime equivalent of arsenic acid to be 14.4569, oxygen being 1.0.

On this supposition, Berzelius's insoluble salts will consist of two primes of base and one of acid; and the acid itself will be a compound of 5 of oxygen $= 5$, $+ 9.5$ of the metallic base $= 14.5$; for direct experiments have shown it to consist of 100 metal, and about 53 oxygen. But $153 : 100 :: 14.5 : 9.5$ nearly.

While Proust and Berzelius concur in assigning the proportion of 53 oxygen to 100 metal in this acid, Thenard states its composition at 56.25 to 100, and Dr. Thomson at 61.4 to 100. By the latter authority, its prime equivalent becomes 4.75 metal $+ 3$ oxygen $= 7.75$; and that of arsenious acid $4.75 + 2 = 6.75$.

All its salts, with the exception of those of potash, soda, and ammonia, are insoluble in water; but except arseniate of bismuth, and one or two more, very soluble in an excess of arsenic acid. Hence, after barytes or oxide of lead has been precipitated by this acid, its farther addition redissolves the precipitate. This is a useful criterion of the acid, joined to its reduction to the metallic state by charcoal, and the other characters already detailed. Sulphuric acid decomposes the arseniates at a low temperature, but the sulphates are decomposed by arsenic acid at a red heat, owing to the greater fixity of the latter. Phosphoric, nitric, muriatic, and fluoric acids, dissolve, and probably convert into subsalts all the arseniates. The whole of them, as well as arsenic acid itself when decomposed at a red heat by charcoal, yield the characteristic garlic smell of the metallic vapour. Nitrate of silver gives a pulverulent brick-coloured precipitate, with arsenic acid. The acid itself does not disturb the transparency of a solution of sulphate of copper; but a neutral arseniate gives with it a bluish-green precipitate; with sulphate of cobalt a dirty red; and with sulphate of nickel, an apple-green precipitate. These precipitates redissolve, on adding a small quantity of the acid which previously held them in solution. Orfila says, that arsenic acid gives, with acetate of copper, a bluish-white precipitate, but that it exercises no action either on the muriate or acetate of cobalt; but with the ammonia-muriate it gives a rose-coloured precipitate. Arsenic acid ought to be accounted a more violent poison than even the arsenious. According to Mr. Brodie it is absorbed, and occasions death by acting on the brain and the heart.

Arsenic acid saturated with potash does not crystallize.

The bin-arseniate of potash is *fabricated* on the great scale in Saxony, by fusing together equal parts of nitre and arsenious acid; dissolving the melted mass, and crystallizing the salt. The crystals are large. By the analysis of M. Berzelius, they consist of arsenic acid 63.87, potash 26.16, water 9.97.—*Ann. de Chim. et de Phys.* xix. 366.

By Dr. Thomson their composition is, arsenic acid 68.5, potash 26.5, water 5. Mitscherlich's statement is in accordance with Berzelius's equivalent number.

With lime water this acid forms a precipitate of arseniate of lime, soluble in an excess of its acid, though insoluble alone.

If arsenic acid be saturated with magnesia, a thick substance is formed near the point of saturation.

Arseniate of barytes is insoluble, and uncrystallizable, but soluble in an excess of the acid.

It consists, by Berzelius, of 57 barytes + 43 arsenic acid. The bin-arseniate of barytes crystallizes. It is made by dissolving the neutral salt in arsenic acid. It contains twice the quantity of acid which exists in the former.

With soda in sufficient quantity to saturate it, arsenic acid forms a salt crystallizable like the acidulous arseniate of potash. To form the neutral arseniate, carbonate of soda should be added to the acid, till the mixture be decidedly alkaline. This salt crystallizes from the concentrated solution. It is much more soluble in hot than in cold water. Pelletier says, that the crystals are hexaëdral prisms terminated by planes perpendicular to their axis.

100 parts of arseniate of soda are composed, by the experiments of Berzelius, of arsenic acid 29.29, soda 15.88, water 54.84. The triple salt, called arseniate of potash and soda, easily crystallizes. It consists, according to the same chemist, of arseniate of potash, 30.24
Arseniate of soda, 26.65
Water, 44.11

The bin-arseniate of soda is obtained by adding arsenic acid to the solution of the neutral salt, till the mixture no longer gives a precipitate with muriate of barytes. It is very soluble in water. It consists of

Arsenic acid, 63.16
Soda, 17.13
Water, 19.71

Combined with ammonia, arsenic acid forms a salt affording rhomboidal crystals analogous to those of the nitrate of soda.

To form this salt, we must add ammonia to the concentrated solution of the acid, till a precipitate fall. On heating the solution, the precipitate is dissolved. If we set the liquid aside, taking care that too much of the ammonia does not exhale, there is formed, after some time, large and beautiful crystals of the neutral salt. The crystals which sometimes fall during the cooling of this solution are a sub-arseniate. The neutral arseniate of ammonia decomposes in the air. It consists of Arsenic acid, 65.28
Ammonia, 19.44
Water, 15.28—*Mitscherlich.*

Bin-arseniate of ammonia is formed by adding arsenic acid to ammonia till litmus paper be strongly reddened by the solution, and till it no longer precipitates muriate of barytes. We then obtain by evaporation crystals which do not change on exposure to the air. It consists, according to Berzelius, of arsenic acid 72.30, ammonia 10.77, water 16.93, in 100 parts. The arseniate of soda and ammonia is formed by mixing the two separate arseniates; and the compound salt gives crystals with brilliant faces. If we redissolve the crystals, and then recrystallize, we should add a little ammonia, otherwise the salt will be acidulous from the escape of some ammonia.

Arsenic acid saturated with alumina forms a thick solution.

By the assistance of a strong fire, as Fourcroy asserts, arsenic acid decomposes the alkaline and earthy sulphates, even that of barytes. Lagrange, however, denies that it acts on any of the neutral salts, except the sulphate of potash and soda, the nitrate of potash, and the muriates of soda and ammonia, and this by means of heat. It does not act on the phosphates.

Arsenic acid does not act on gold or platina: neither does it on mercury or silver without the aid of a strong heat; but it oxidizes copper, iron, lead, tin, zinc, bismuth, antimony, cobalt, nickel, manganese, and arsenic.

This acid is not used in the arts, at least directly, though indirectly it forms a part of some compositions used in dyeing. It is likewise one of the mineralizing acids combined by nature with some of the metallic oxides. See SALTS (TABLE OF).

ACID (ARSENIOUS). Fourcroy was the first who distinguished by this name the white arsenic of the shops, which Scheele had proved to be a compound of the metal arsenic with oxygen.

This acid, which is one of the most virulent poisons known, frequently occurs in a native state, if not very abundantly; and it is obtained in roasting several ores, particularly those of cobalt. In the chimneys of the furnaces where this operation is conducted, it generally condenses in thick semitransparent masses; though sometimes it assumes the form of a powder, or of little needles, in which state it was formerly called flowers of arsenic.

The arsenious acid reddens the most sensible blue vegetable colours, though it turns the syrup of violets green. On exposure to the air it becomes opaque, and covered with a slight efflorescence. Thrown on incandescent coals, it evaporates in white fumes, with a strong smell of garlic. In close vessels it is volatilized; and, if the heat be strong, vitrified. The result of this vitrification is a transparent glass, capable of crystallizing in tetraëdra, the angles of which are truncated. It is easily altered by hydrogen and carbon, which deprive it of its oxygen at a red heat, and reduce the metal, the one forming water, the other carbonic acid, with the oxygen taken from it; as it is by phosphorus, and by sulphur, which are in part converted into acids by its oxygen, and in part form an arsenical phosphuret or sulphuret with the arsenic reduced to the metallic state. Hence Margraaf and Pelletier, who particularly examined the phosphurets of metals, have asserted they might be formed with arsenious acid. Its specific gravity is 3.7.

It is soluble in thirteen times its weight of boiling water, but requires eighty times its weight of cold. The solution crystallizes and the acid assumes the form of regular tetraëdons according to Fourcroy; but according to Lagrange, of octaëdrons, and these frequently varying in figure by different laws of decrement. It crystallizes much better by slow evaporation than by simple cooling.

The solution is very acrid, reddens blue colours, unites with the earthy bases, and decomposes the alkaline sulphurets. Arsenious acid is also soluble in oils, spirits, and alcohol; the last taking up from 1 to 2 per cent. It is composed by Berzelius of 9.5 of metal + 3 oxygen; and its prime equivalent is therefore 12.5. But Dr. Thomson considers it, as a compound of 4.75 metal + 2 oxygen = 6.75. Dr. Wollaston first observed, that when a mixture of it with quicklime is heated in a glass tube, at a certain temperature, ignition suddenly pervades the mass, and metallic arsenic sublimes. As arseniate of lime is found at the bottom of the tube, we perceive that a portion of the arsenious acid is robbed of its oxygen, to complete the acidification of the rest.

The action of the other acids upon the arsenious is very different from that which they exert on the metal arsenic. By boiling, sulphuric acid dissolves a small portion of it, which is precipitated as the solution cools. The nitric acid does not dissolve it, but by the help of heat converts it into arsenic acid. Neither the phosphoric nor the carbonic acid acts upon it; yet it enters into a vitreous combination with the phosphoric and boracic acids. The muriatic acid dissolves it by means of heat, and forms with it a volatile compound, which water precipitates; and aqueous chlorine acidifies it completely, so as to convert it into arsenic acid.

The arsenious acid combines with the earthy and alkaline bases. The earthy arseniates possess little solubility; and hence the solutions of barytes, strontian, and lime, form precipitates with that of arsenious acid.

With the fixed alkalis the arsenious acid forms viscid arsenites, which do not crystallize, and which are decomposable by fire, the arsenious acid being volatilized by the heat.

With ammonia it forms a salt capable of crystallization.

Neither the earthy nor alkaline arsenites have yet been much examined.

The nitrates act on the arsenious acid in a very remarkable manner. On treating the nitrates and arsenious acid together, the nitrous acid, or nitrous vapour, is extricated in a state very difficult to be confined, as Kunckel long ago observed: part of its oxygen is absorbed by the arsenious acid; it is thus converted into arsenic acid, and an arseniate is left in the retort. The same phenomena take place on detonating nitrates with arsenious acid; for it is still sufficiently combustible to produce a detonation, in which no sparks are seen, it is true, but with commotion and effervescence; and a true arseniate remains at the bottom of the crucible. It was in this way chemists formerly prepared their fixed arsenic, which was the acidulous arseniate of potash. The nitrate of ammonia exhibits different phenomena in its decomposition by arsenious acid, and requires considerable precaution. Pelletier, having mixed equal quantities, introduced the mixture into a large retort of coated glass, placed in a reverberatory furnace, with a globular receiver. He began with a very slight fire; for the decomposition is so rapid, and the nitrous vapours issue with such force, that a portion of the arsenious acid is carried off undecomposed, unless you proceed very gently. If due care be taken that the decomposition proceeds more slowly, nitrous acid first comes over; if the fire be continued, or increased, ammonia is next evolved; and lastly, if the fire be urged, a portion of oxide of arsenic sublimes in the form of a white powder, and a vitreous mass remains in the retort, which powerfully attacks and corrodes it. This is arsenic acid. The chlorate of potash, too, by completely oxidizing the arsenious acid, converts it into arsenic acid, which, by the assistance of heat, is capable of decomposing the muriate of potash that remains.

Arsenious acid is used in numerous instances in the arts, under the name of white arsenic, or of arsenic simply. In many cases it is reduced, and acts in its metallic state.

Many attempts have been made to introduce it into medicine; but as it is known to be one of the most violent poisons, it is probable that the fear of its bad effects may deprive society of the advantages it might afford in this way. An arsenite of potash was extensively used by the late Dr. Fowler of York, who published a treatise on it, in intermittent and remittent fevers. He found it extremely efficacious in periodical headach, and as a tonic in nervous and other disorders. Externally it has been employed as a caustic to extirpate cancer, combined with sulphur, with bole, with antimony, and with the leaves of crowfoot; but it always gives great pain, and is not unattended with danger.

It has been more lately used as an alterative with advantage in chronic rheumatism. The symptoms which show the system to be *arsenified* are thickness, redness, and stiffness of the *palpebræ*, soreness of the gums, ptyalism, itching over the surface of the body, restlessness, cough, pain at stomach, and headach. When the latter symptoms supervene, the administration of the medicine ought to be immediately suspended. It has also been recommended against chincough; and has been used in considerable doses with success, to counteract the poison of venomous serpents.

Since it acts on the animal economy as a deadly poison in quantities so minute as to be insensible to the taste when diffused in water or other vehicles, it has been often given with criminal intentions and fatal effects. It becomes therefore a matter of the utmost importance to present a systematic view of the phenomena characteristic of the poison, its operation, and consequences.

1st, It is a dense substance, subsiding speedily after agitation in water. I find its sp. gr. to vary from 3.728 to 3.730, which is a little higher than the number given above: 72 parts dissolve in 1000 of boiling water, of which 30 remain in it after it cools. Cold water dissolves, however, only $\frac{8}{1000}$ or $\frac{1}{10}$ of the preceding quantity. This water makes the syrup of violets green, and reddens litmus paper. Lime water gives a fine white precipitate with it of arsenite of lime, soluble in an excess of the arsenious solution; sulphuretted hydrogen gas, and hydrosulphuretted water, precipitate a golden yellow sulphuret of arsenic. By this means $\frac{1}{100000}$ of arsenious acid may be detected in water. This sulphuret dried on a filter, and heated in a glass tube with a bit of caustic potash, is decomposed in a few minutes, and converted into sulphuret of potash, which remains at the bottom, and metallic arsenic of a bright steel lustre, which sublimes, coating the sides of the tube. The hydrosulphurets of alkalis do not affect the arsenious solution, unless a drop or two of nitric or muriatic acid be poured in, when the characteristic golden yellow precipitate falls. Nitrate of silver is decomposed by the arsenious acid, and a very peculiar yellow arsenite of silver precipitates; which, however, is apt to be redissolved by nitric acid, and therefore a very minute addition of ammonia is requisite. Even this, however, also, if in much excess, redissolves the silver precipitate.

As the nitrate of silver is justly regarded as one of the best precipitant tests of arsenic, the mode of using it has been a subject of much discussion. This excellent test was first proposed by Mr. Hume of Long Acre, in May 1809. *Phil. Mag.* xxxiii. 401.—The presence of muriate of soda indeed, in the arsenical solution, obstructs, to a certain degree, the operation of this reagent. But that salt is almost always present in the *primæ viæ*, and is an usual ingredient in soups, and other vehicles of the poison. If, after the water of ammonia has been added, (by plunging the end of a glass rod dipped in it into the supposed poisonous liquid), we dip another rod into a solution of pure nitrate of silver, and transfer it into the arsenious solution, either a fine yellow cloud will be formed, or at first merely a white curdy precipitate. But at the second or third immersion of the nitrate rod, a central spot of yellow will be perceived surrounded with the white muriate of silver. At the next immersion this yellow cloud on the surface will become very conspicuous. Sulphate of soda does not interfere in the least with the silver test.

The ammoniaco-sulphate, or rather ammoniaco-acetate of copper, added in a somewhat dilute state to an arsenious solution, gives a fine grass-green and very characteristic precipitate. This green arsenite of copper, well washed, being acted on by an excess of sulphuretted hydrogen water, changes its colour, and becomes of a brownish-red. Ferro-prussiate of potash changes it into a blood-red. Nitrate of silver converts it into the yellow arsenite of silver.

Lastly, if the precipitate be dried on a filter, and placed on a bit of burning coal, it will diffuse a garlic odour. The cupreous test will detect $\frac{1}{110000}$ of the weight of the arsenic in water.

The voltaic battery, made to act by two wires on a little arsenious solution placed on a bit of window-glass, developes metallic arsenic at the negative pole; and if this wire be copper, it will be whitened like tombac.

We may here remark, however, that the most elegant mode of using all these precipitation reagents is upon a plane of glass; a mode practised by Dr. Wollaston in general chemical research, to an extent, and with a success, which would be incredible in other hands than his. Concentrate by heat in a capsule the suspected poisonous solution, having previously filtered it if necessary. Indeed, if it be very much disguised with animal or vegetable matters, it is better first of all to evaporate to dryness, and by a few drops of nitric acid to dissipate the organic products. The clear liquid being now placed in the middle of the bit of glass, lines are to be drawn out from it in different directions. To one of these a particle of weak ammoniacal water being applied, the weak nitrate of silver may then be brushed over it with a hair pencil. By placing the glass in different lights, either over white paper or obliquely before the eye, the slightest change of tint will be perceived. The ammoniaco-acetate should be applied to another filament of the drop, deut-acetate of iron to a third, weak ammoniaco-acetate of cobalt to a fourth, sulphuretted water to a fifth, lime water to a sixth, a drop of violet-syrup to a seventh, and the two galvanic wires at the opposite edges of the whole. Thus with one single drop of solution many exact experiments may be made.

But the chief, the decisive trial or *experimentum crucis* remains, which is to take a little of the dry matter, mix it with a small pinch of dry black flux, put it into a narrow glass tube sealed at one end, and after cleansing its sides with a feather, urge its bottom with a blowpipe till it be distinctly red-hot for a minute. Then garlic fumes will be smelt, and the steel-lustred coating of metallic arsenic will be seen in the tube about one-fourth of an inch above its bottom. Cut the tube across at that point by means of a fine file, detach the scale of arsenic with the point of a penknife; put a fragment of it into the bottom of a small wine-glass along with a few drops of ammoniaco-acetate of copper, and triturate them well together for a few minutes with a round-headed glass rod. The mazarine blue colour will soon be transmuted into a lively grass green, while the metallic scale will vanish. Thus we distinguish perfectly between a particle of metallic arsenic and one of animalized charcoal. Another particle of the scale may be placed between two smooth and bright surfaces of copper, with a touch of fine oil; and whilst they are firmly pressed together, exposed to a red heat. The tombac alloy will appear as a white stain. A third particle may be placed on a bit of heated metal, and held a little under the nostrils, when the garlic odour will be recognized. No danger can be apprehended, as the fragment need not exceed the tenth of a grain.

It is to be observed, that one or two of the precipitation tests may be equivocal from admixtures of various substances. Thus tincture of ginger gives with the cupreous re-agent a green precipitate; and the writer of this article was at first led to suspect from that appearance, that an empirical tincture, put into his hands for examination, did contain arsenic. But a careful analysis satisfied him of its genuineness. Tea covers arsenic from the cupreous test. Such poisoned tea becomes by its addition of an obscure olive or violet red, but yields scarcely any precipitate. Sulphuretted hydrogen, however, throws down a fine yellow sulphuret of arsenic.

To remove the colouring matter of a vegetable or animal kind Mr. Phillips has very properly recommended to mix the poisoned liquid with well washed animal charcoal (bone-black) and thereafter to filter, before applying the tests, 100 grains of black mixed with 500 of port wine, containing 1 grain of arsenious acid, became so de-coloured, as to admit of the application of tests.

A good way of obviating all these sources of fallacy is to evaporate carefully to dryness, and expose the residue to heat in a glass tube. The arsenic sublimes, and may be afterwards operated on without ambiguity. M. Orfila has gone into ample details on the modifications produced by wine, coffee, tea, broth, &c. on arsenical tests, of which a good tabular abstract is given in Mr. Thomson's London Dispensatory. But it is evident that the differences in these menstrua, as also in beers, are so great as to render precipitations and changes of colour by reagents very unsatisfactory witnesses in a case of life and death. Hence the method of evaporation above described should never be neglected. Should the arsenic be combined with oil, the mixture ought to be boiled with water, and the oil then separated by the capillary action of wick-threads. If with resinous substances, these may be removed by oil of turpentine, not by alcohol (as directed by Dr. Black), which is a good solvent of arsenious acid. It may moreover be observed, that both tea and coffee should be freed from their tannin by gelatin, which does not act on the arsenic, previous to the use of reagents for the poison. When one part of arsenious acid in watery solution is added to ten parts of milk, the sulphuretted hydrogen present in the latter, occasions the white colour to pass into a canary yellow; the cupreous test gives it a slight green tint, and the nitrate of silver produces no visible change, though even more arsenic be added; but the hydrosulphurets throw down a golden yellow, with the aid of a few drops of an acid. The liquid contained in the stomach of a rabbit poisoned with a solution of 3 grains of arsenious acid, afforded a white precipitate with nitrate of silver, greyish-white with lime water, green with the ammoniaco-sulphate, and deep yellow with sulphuretted hydrogen water.

The *preceding* copious description of the habitudes *of* arsenious acid in different circumstances is equally applicable to the soluble arsenites. Their poisonous operation, as well as that of the arsenic acid, has been satisfactorily referred by Mr. Brodie to the suspension of the functions of the heart and brain, occasioned by the absorption of these substances into the circulation, and their consequent determination to the nervous system and the alimentary canal. This proposition was established by numerous experiments on rabbits and dogs. Wounds were inflicted, and *arsenic* being applied to them, it was found that in a short time death supervened, with the same symptoms of inflammation of the stomach and bowels as if the poison had been swallowed.

He divides the morbid affections into three classes: 1st, Those depending on the nervous system, as palsy at first of the posterior extremities, and then of the rest of the body, convulsions, dilatation of the pupils, and general insensibility: 2d, Those which indicate disturbance in the organs of circulation: for example, the feeble, slow, and intermitting pulse, weak contractions of the heart immediately after death, and the impossibility of prolonging them, as may be done in sudden deaths from other causes, by artificial respiration: 3d, Lastly, Those which depend on lesion of the alimentary canal, as the pains of the abdomen, nauseas, and vomitings, in those animals which were suffered to vomit. At one time it is the nervous system that is most remarkably affected, and at another the organs of circulation. Hence inflammation of the stomach and intestines ought not to be *considered* as the immediate cause of death, in the greater number of cases of poisoning by arsenic. However, should an animal not sink under the first violence of the poison, if the inflammation has had time to be developed, there is no doubt that it may destroy life. Mr. Earle states, that a woman who had taken arsenic resisted the alarming symptoms which at first appeared, but died on the fourth day. On opening her body the mucous membrane of the stomach and intestines was ulcerated to a great extent. Authentic cases of poison are recorded, where no trace of inflammation was perceptible in the *primæ viæ*.

The effects of arsenic have been graphically represented by Dr. Black: "The symptoms produced by a dangerous dose of arsenic begin to appear in a quarter of an hour, or not much longer, after it is taken. First sickness, and great distress at stomach, soon followed by thirst, and burning heat in the bowels. Then come on violent vomiting, and severe colic pains, and excessive and painful purging. This brings on faintings with cold sweats, and other signs of great debility. To this succeed painful cramps, and contractions of the legs and thighs, and extreme weakness, and death." Similar results have followed the incautious sprinkling of schirrous ulcers with powdered arsenic, or the application of arsenical pastes. The following more minute specification of symptoms is given by Orfila: "An austere taste in the mouth; frequent ptyalism; continual spitting; constriction of the *pharynx* and *œsophagus*; teeth set on edge; hiccups; nausea; vomiting of brown or bloody matter; anxiety; frequent fainting fits; burning heat at the *precordia*; inflammation of the lips, tongue, palate, throat, stomach; acute pain of stomach, rendering the mildest drinks intolerable; black stools of an indescribable fœtor; pulse frequent, oppressed, and irregular, sometimes slow and unequal; palpitation of the heart; *syncope*; unextinguishable thirst; burning sensation over the whole body, resembling a consuming fire; at times an icy coldness; difficult respiration; cold sweats; scanty urine, of a red or bloody appearance; altered expression of countenance; a livid circle round the eyelids; swelling and itching of the whole body, which becomes covered with livid spots, or with a miliary eruption; prostration of strength; loss of feeling, especially in the feet and hands; delirium, convulsions, sometimes accompanied with an insupportable priapism; loss of the hair; separation of the epidermis; horrible convulsions; and death."

It is uncommon to observe all these frightful symptoms combined in one individual; sometimes they are altogether wanting, as is shown by the following case, related by M. Chaussier: a robust man of middle age swallowed arsenious acid in large fragments, and died without experiencing other symptoms than slight *syncopes*. On opening his stomach, it was found to contain the arsenious acid in the very same state in which he had swallowed it. There was no appearance whatever of erosion or inflammation in the intestinal canal. Etmuller mentions a young girl's being poisoned by arsenic, and whose stomach and bowels were sound to all appearance, though the arsenic was found in them. In general, however, inflammation does extend along the whole canal, from the mouth to the *rectum*. The stomach and *duodenum* present frequently gangrenous points, eschars, perforations of all their coats; the villous coat in particular, by this and all other corrosive poisons, is commonly detached, as if it were scraped off or reduced into a paste of a reddish-brown colour. From these considerations we may conclude, that from the existence or non-existence of intestinal lesions, from the extent or seat of the symptoms alone, the physician should not venture to pronounce definitively on the fact of poisoning.

The result of Mr. Brodie's experiments on brutes teaches, that the inflammations of the intestines and stomach are more severe when the poison has been applied to an external wound, than when it has been thrown into the stomach itself.

The best remedies against this poison in the stomach are copious draughts of bland liquids of a mucilaginous consistence, to inviscate the powder, so as to procure its complete ejection by vomiting. Sulphuretted hydrogen condensed in water is the only direct antidote to its virulence; Orfila having found, that when dogs were made to swallow that liquid, after getting a poisonous dose of arsenic, they recovered, though their œsophagus was tied to prevent vomiting; but when the same dose of poison was administered in the same circumstances, without the sulphuretted water, that it proved fatal.

When the *viscera* are to be subjected after death to chemical investigation, a ligature ought to be thrown round the œsophagus and the beginning of the colon, and the intermediate stomach and intestines removed. Their liquid contents should be emptied into a basin; and thereafter a portion of hot water introduced into the stomach, and worked thoroughly up and down this *viscus*, as well as the intestines.

After filtration, a portion of the liquid should be concentrated by evaporation in a porcelain capsule, and then submitted to the proper reagents above described. We may also endeavour to extract from the stomach by digestion in boiling water, with a little ammonia, the arsenical impregnation, which has been sometimes known to adhere in minute particles with wonderful obstinacy. This precaution ought therefore to be attended to. The heat will dissipate the excess of ammonia in the above operation; whereas by adding potash or soda, as prescribed by the German chemists, we introduce animal matter in alkaline solution, which complicates the investigation.

The matters rejected from the patient's bowels before death should not be neglected. These, generally speaking, are best treated by cautious evaporation to dryness: but we must beware of heating the residuum to 400°, since at that temperature, and perhaps a little under it, the arsenious acid itself sublimes.

Vinegar, hydroguretted alkaline sulphurets, and oils, are of no use as counterpoisons. Indeed, when the arsenic exists in substance in the stomach, even sulphuretted hydrogen water is of no avail, however effectually it neutralize an arsenious solution. Syrups, linseed tea, decoction of mallows, or tragacanth, and warm milk, should be administered as copiously as possible, and vomiting provoked by tickling the fauces with a feather. Clysters of a similar nature may be also employed. Many persons have escaped death by having taken the poison mixed with rich soups; and it is well known, that when it is prescribed as a medicine, it acts most beneficially when given soon after a meal. These facts have led to the prescription of butter and oils; the use of which is, however, not advisable, as they screen the arsenical particles from more proper menstrua, and even appear to aggravate its virulence. Morgagni, in his great work on the seats and causes of disease, states, that at an Italian feast the dessert was purposely sprinkled over with arsenic instead of flour. Those of the guests who had previously ate and drank little, speedily perished; those who had their stomachs well filled, were saved by vomiting. He also mentions the case of three children who ate a vegetable soup poisoned with arsenic. One of them, who took only two spoons-full, had no vomiting, and died; the other two, who had eaten the rest, vomited, and got well. Should the poisoned patient be incapable of vomiting, a tube of caoutchouc, capable of being attached to a syringe, may be had recourse to. The tube first serves to introduce the drink, and to withdraw it after a few instants.

The following tests of arsenic and corrosive sublimate have been lately proposed by Brugnatelli: take the starch of wheat boiled in water until it is of a proper consistence, and recently prepared; to this add a sufficient quantity of iodine to make it of a blue colour; it is afterwards to be diluted with pure water until it becomes of a beautiful azure. If to this, some drops of a watery solution of arsenic be added, the colour changes to a reddish hue, and finally vanishes. The solution of corrosive sublimate poured into iodine and starch, produces almost the same change as arsenic; but if to the fluid acted on by the arsenic we add some drops of sulphuric acid, the original blue colour is restored with more than its original brilliancy, while it does not restore the colour to the corrosive sublimate mixture. See SALT.

ACID (BENZOIC). The usual method of obtaining this acid affords a very elegant and pleasing example of the chemical process of sublimation. For this purpose a thin stratum of powdered benzoin is spread over the bottom of a glazed earthen pot, to which a tall conical paper covering is fitted: gentle heat is then to be applied to the bottom of the pot, which fuses the benzoin, and fills the apartment with a fragrant smell, arising from a portion of essential oil and acid of benzoin, which are dissipated into the air; at the same time the acid itself rises very suddenly in the paper head, which may be occasionally inspected at the top, though with some little care, because the fumes will excite coughing. This acid sublimate is condensed in the form of long needles, or straight filaments of a white colour, crossing each other in all directions. When the white acid ceases to rise, the cover may be changed, a new one applied, and the heat raised: more flowers of a yellowish colour will then rise, which require a second sublimation to deprive them of the empyreumatic oil they contain.

The sublimation of the acid of benzoin may be conveniently performed by substituting an inverted earthen pan instead of the paper cone. In this case the two pans should be made to fit, by grinding on a stone with sand, and they must be luted together with paper dipped in paste. This method seems preferable to the other, where the presence of the operator is required elsewhere; but the paper head can be more easily inspected and changed. The heat applied must be very gentle, and the vessels ought not to be separated till they have become cool.

The quantity of acid obtained in these methods differs according to the management, and probably also from difference of purity, and in other respects, of the balsam itself. It usually amounts to no more than about one-eighth part of the whole weight. Indeed Scheele says, not more than a tenth or twelfth. The whole acid of benzoin is obtained with greater certainty in the humid process of Scheele: this consists in boiling the powdered balsam with lime water, and afterwards separating the lime by the addition of muriatic acid. Twelve ounces of water are to be poured upon four ounces of slaked lime; and, after the ebullition is over, eight pounds, or ninety-six ounces, more of water are to be added: a pound of finely-powdered benzoin being then put into a tin vessel, six ounces of the lime water are to be added, and mixed well with the powder; and afterwards the rest of the lime water in the same gradual manner, because the benzoin would coagulate into a mass, *if the whole* were added at once. This mixture must be gently boiled for half an hour with constant agitation, and afterwards suffered to cool and subside during an hour. The supernatant liquor must be decanted, and the residuum boiled with eight pounds more of lime water; after which the same process is to be once more repeated: the remaining powder must be edulcorated on the filter by affusions of hot water. Lastly, all the decoctions, being mixed together, must be evaporated to two pounds, and strained into a glass vessel.

This fluid consists of the acid of benzoin combined with lime. After it is become cold, a quantity of muriatic acid must be added, with constant stirring, until the fluid tastes a little sourish. During this time the last-mentioned acid unites with the lime, and forms a soluble salt, which remains suspended, while the less soluble acid of benzoin, being disengaged, falls to the bottom in powder. By repeated affusions of cold water upon the filter, it may be deprived of the muriate of lime and muriatic acid with which it may happen to be mixed. If it be required to have a shining appearance, it may be dissolved in a small quantity of boiling water, from which it will separate in silky filaments by cooling. By this process the benzoic acid may be procured from other substances, in which it exists.

Mr. Hatchell has shown, that, by digesting benzoin in hot sulphuric acid, very beautiful crystals are sublimed. This is perhaps the best process for extracting the acid. If we concentrate the urine of horses or cows, and pour muriatic acid into it, a copious precipitate of benzoic acid takes place. This is the cheapest source of it.

The acid of benzoin is so inflammable, that it burns with a clear yellow flame without the assistance of a wick. The sublimed flowers in their purest state, as white as ordinary writing paper, were fused into a clear transparent yellowish fluid, at the two hundred-and-thirtieth degree of Fahrenheit's thermometer, and at the same time began to rise in sublimation. It is probable that a heat somewhat greater than this may be required to separate it from the resin. It is strongly disposed to take the crystalline form in cooling. The concentrated sulphuric and nitric acids dissolve this concrete acid, and it is again separated without alteration, by adding water. Other acids dissolve it by the assistance of heat, from which it separates by cooling, unchanged. It is plentifully soluble in ardent spirit, from which it may likewise be separated by diluting the spirit with water. It readily dissolves in oils, and in melted tallow. If it be added in a small proportion to this last fluid, part of the tallow congeals before the rest, in the form of white opaque clouds. If the quantity of acid be more considerable, it separates in part by cooling, in the form of needles or feathers. In the destructive distillation of tallow, benzoic acid is said to be formed.

At the temperature of boiling water, oil of turpentine dissolves about its own weight of benzoic acid, but the solution becomes concrete on cooling.

Pure benzoic acid is in the form of a light powder, evidently crystallized in fine needles, the figure of which is difficult to be determined from their smallness. It has a white and shining appearance; but when contaminated by a portion of volatile oil, is yellow or brownish. It is not brittle, as might be expected from its appearance, but has rather a kind of ductility and elasticity, and, on rubbing in a mortar, becomes a sort of paste. Its taste is acrid, hot, acidulous, and bitter.

It reddens the infusion of litmus, but not syrup of violets. It has a peculiar aromatic smell, but not strong unless heated. This, however, appears not to belong to the acid; for Mr. Giese informs us, that on dissolving the benzoic acid in as little alcohol as possible, filtering the solution, and precipitating by water, the acid will be obtained pure, and void of smell, the odorous oil remaining dissolved in the spirit. Its specific gravity is 0.667. It is not perceptibly altered by the air, and has been kept in an open vessel twenty years without losing any of its weight. None of the combustible substances have any effect on it; but it may be refined by mixing it with charcoal powder and subliming, being thus rendered much whiter and better crystallized. It is not very soluble in water. Wenzel and Lichtenstein say four hundred parts of cold water dissolve but one, though the same quantity of boiling water dissolves twenty parts, nineteen of which separate on cooling.

Berzelius states the composition of benzoic acid to be carbon 74.41, oxygen 20.43, and hydrogen 5.16 in 100. From the benzoate of lead, he deduces the prime equivalent to be 14.893. By my experiments, its components are carbon 66.74, oxygen 28.32, and hydrogen 4.94; and by saturation with ammonia its prime equivalent appeared to be 14.5, to oxygen 1.

The benzoic acid unites without much difficulty with the earthy and alkaline bases.

The benzoate of barytes is soluble and crystallizes. That of lime is very soluble in water, though much less in cold than in hot, and crystallizes on cooling. The benzoate of magnesia is soluble, crystallizable, and a little deliquescent. That of alumina is very soluble, crystallizes in dendrites, is deliquescent, and has an acerb and bitter taste. The benzoate of potash crystallizes on cooling in little compacted needles. The benzoate of soda is very crystallizable, very soluble, and not deliquescent like that of potash, but it is decomposable by the same means. It is sometimes found native in the urine of graminivorous quadrupeds, but by no means so abundantly as that of lime. The benzoate of ammonia is volatile, and decomposable by all the acids and all the bases. The solutions of all the benzoates, when drying on the sides of a vessel wetted with them, form dendritical crystallizations.

Trommsdorf found in his experiments, that benzoic acid united readily with metallic oxides.

The benzoates are all decomposable by heat, which, when it is slowly applied, first separates a portion of the acid in a vapour, that condenses in crystals. The soluble benzoates are decomposed by the powerful acids, which separate their acid in a crystalline form. The benzoate of ammonia has been proposed by Berzelius as a reagent for precipitating red oxide of iron from perfectly neutral solutions. See SALTS (TABLE of.)

ACID (BOLETIC). An acid extracted from the expressed juice of the *boletus pseudo igniarius* by M. Braconnot. This juice, concentrated to a syrup by a very gentle heat, was acted on by strong alcohol. What remained was dissolved in water. When nitrate of lead was dropped into this solution, a white precipitate fell, which, after being well washed with water, was decomposed by a current of sulphuretted hydrogen gas. Two different acids were found in the liquid after filtration and evaporation. One in permanent crystals was BOLETIC acid; the other was a small proportion of phosphoric acid. The former was purified by solution in alcohol, and subsequent evaporation.

It consists of irregular four-sided prisms, of a white colour, and permanent in the air. Its taste resembles cream of tartar; at the temperature of 68° it dissolves in 180 times its weight of water, and in 45 of alcohol. Vegetable blues are reddened by it. Red oxide of iron, and the oxides of silver and mercury, are precipitated by it from their solutions in nitric acid; but lime and barytes waters are not affected. It sublimes when heated, in white vapours, and is condensed in a white powder. *Ann. de Chimie*, lxxx.

ACID (BORACIC). The salt composed of this acid and soda had long been used both in medicine and the arts under the name of borax, when Homberg first obtained the acid separate in 1702, by distilling a mixture of borax and sulphate of iron. Lemery the younger soon after discovered that it could be obtained from borax equally by means of the nitric or muriatic acid; Geoffroy detected soda in borax; and at length Baron proved by a number of experiments, that borax is a compound of soda and a peculiar acid.

To procure the acid, dissolve borax in hot water, and filter the solution; then add sulphuric acid by little and little, till the liquid has a sensibly acid taste. Lay it aside to cool, and a great number of small shining laminated crystals will form. These are the boracic acid. They are to be washed with cold water, and drained upon paper.

Boracic acid thus procured is in the form of thin irregular hexagonal scales, of a silvery whiteness, having some resemblance to spermaceti, and the same kind of greasy feel. It has a sourish taste at first, then makes a bitterish cooling impression, and at last leaves an agreeable sweetness. Pressed between the teeth, it is not brittle but ductile. It has no smell; but, when sulphuric acid is poured on it, a transient odour of musk is produced. Its specific gravity in the form of scales is 1.479; after it has been fused, 1.803. It is not altered by light. Exposed to the fire, it swells up, from losing its water of crystallization, and in this state is called calcined boracic acid. It melts a little before it is red-hot, without perceptibly losing any water, but it does not flow freely till it is red, and then less than the borate of soda. After this fusion it is a hard transparent glass, becoming a little opaque on exposure to the air, without abstracting moisture from it, and unaltered in its properties, for on being dissolved in boiling water it crystallizes as before. This glass is used in the composition of false gems.

Boiling water scarcely dissolves one-fiftieth part, and cold water much less. When this solution is distilled in close vessels, part of the acid rises with the water, and crystallizes in the receiver. It is more soluble in alcohol, and alcohol containing it burns with a green flame, as does paper dipped in a solution of boracic acid.

Crystallized boracic acid is a compound of 57 parts of acid and 43 of water. The honour of discovering the radical of *boracic acid* is divided between Sir H. Davy and MM. Gay Lussac and Thenard. The first, on applying his powerful voltaic battery to it, obtained a chocolate-coloured body in small quantity; but the two latter chemists, by acting on it and potassium in equal quantities, at a low red heat, formed boron and sub-borate of potash. For a small experiment, a glass tube will serve, but on a greater scale a copper tube is to be preferred. The potassium and boracic acid, perfectly dry, should be intimately mixed before exposing them to heat. On withdrawing the tube from the fire, allowing it to cool, and removing the cork which loosely closed its mouth, we then pour successive portions of water into it, till we detach or dissolve the whole matter. The water ought to be heated each time. The whole collected liquids are allowed to settle; when, after washing the precipitate till the liquid ceases to affect syrup of violets, we dry the boron in a capsule, and then put it into a phial out of contact of air. Boron is solid, tasteless, inodorous, and of a greenish-brown colour. Its specific gravity is somewhat greater than water.

The prime equivalent of boracic acid has been inferred from the borate of ammonia, to be about 2.7 or 2.8; oxygen being 1.0; and it probably consists of 2.0 of oxygen + 0.8 of boron. But by MM. Gay Lussac and Thenard, the proportions would be 2 of boron to 1 of oxygen.

The boracic acid has a more powerful attraction for lime than for any other of the bases, though it does not readily form borate of lime by adding a solution of it to lime water, or decomposing by lime water the soluble alkaline borates. In either case an insipid white powder, nearly insoluble, which is the borate of lime, is however precipitated. The borate of barytes is likewise an insoluble, tasteless, white powder.

Bergman has observed, that magnesia, thrown by little and little into a solution of boracic acid, dissolved slowly, and the liquor on evaporation afforded granulated crystals without any regular form: that these crystals were fusible in the fire without being decomposed; but that alcohol was sufficient to separate the boracic acid from the magnesia. If however some of the soluble magnesian salts be decomposed by alkaline borates in a state of solution, an insipid and insoluble borate of magnesia is thrown down. It is probable, therefore, that Bergman's salt was a borate of magnesia dissolved in an excess of boracic acid; which acid being taken up by the alcohol, the true borate of magnesia was precipitated in a white powder, and mistaken by him for magnesia.

One of the best known combinations of this acid is the native magnesio-borate of Kalkberg, near Lunenburg. See BORACITE.

The borate of potash is but little known.

With soda the boracic acid forms a salt of considerable use in the arts, and long known by the name of borax.

According to M. Arfwredson, borax consists in the dry or calcined state of acid 68.9, soda 31.1 in 100. It was analyzed by mixing it with three or four times its weight of finely powdered fluor spar, free from silica, and a sufficient quantity of sulphuric acid. On evaporating the mixture, and exposing it to a red heat, all the boracic acid was expelled as fluoboric acid gas, and from the resulting sulphate of soda the quantity of this alkaline base was inferred.

Gmelin found borax to contain in the crystallized state 46.6 *per cent.* of water; and in the dry state he regards it as a compound of two parts by weight of acid and one of base. Borax, therefore, instead of being called, as heretofore, the sub-borate of soda, should be viewed as a bi-borate.

From M. Arfwredson's analysis the prime equivalent of boracic acid would seem to be 4.4, and from M. Gmelin's 4. Dr. Thomson makes it only 3. More recently M. Soubeirons finds borax to consist of acid 67.584, base 32.416; whence the equivalent of boracic acid comes out 4.175.

Borate of ammonia forms in small rhomboidal crystals, easily decomposed by fire; or in scales, of a pungent urinous taste, which lose the crystalline form, and grow brown on exposure to the air.

The boracic acid unites with silex by fusion, and forms with it a solid and permanent vitreous compound.

The boracic acid has been found in a disengaged state in several lakes of hot mineral waters near Monte Rotondo, Berchiaio, and Castellonuovo in Tuscany, in the proportion of nearly nine grains in a hundred of water, by M. Hoeffer. M. Mascagni also found it adhering to schistus, on the borders of lakes, of an obscure white, yellow, or greenish colour, and crystallized in the form of needles.

He has likewise found it in combination with ammonia. See SALT.

ACID (BROMIC). When brome is agitated with a sufficiently concentrated solution of potash, two very different compounds are formed. Hydrobromate of potash remains dissolved in the liquid. A white powder precipitates to the bottom of the vessel, of a crystalline aspect, which fuses on red-hot coals like nitre, and is transformed by heat into bromide of potassium, with the disengagement of oxygen. This crystalline powder is bromate of potash. It is scarcely soluble in alkohol, but in boiling water it dissolves pretty copiously, from which solution, by cooling, there fall down needles grouped together. When crystallized by evaporation, the bromate is deposited in crystalline plates, with little lustre. It deflagrates on ignited charcoal; and when mixed in powder with sublimed sulphur, it detonates on being struck by a hammer.

The solution of this salt yields a precipitate with nitrate of silver. This white and pulverulent precipitate, blackening with difficulty on contact with light, is thereby distinguished from bromide of silver, which is yellowish, curdy, and easily affected by the sunbeams.

The salts of lead, which produce an abundant crystalline precipitate, with hydrobromate of potash, have no effect on the bromate.

Bromate of barytes forms acicular crystals, soluble in boiling water, scarcely so in cold water, and melting with a green flame on burning coals.

On pouring dilute sulphuric acid into the solution of bromate of barytes, so as to precipitate the whole of the base, a dilute solution of bromic acid is obtained. The bromate of barytes is best obtained for this purpose by combining chlorine with brome, and by placing this compound in contact with a solution of that earth.

By slow evaporation the greater part of the water may be removed. It then acquires a syrupy consistence. If the temperature be raised higher with the view of expelling the water completely, one portion of the acid evaporates, and the other is decomposed into oxygen and brome. The same change seems to ensue when the concentration is pushed too far by the action of a surface of sulphuric acid in vacuo. Water thus appears to be necessary to the constitution of bromic acid.

This acid first reddens litmus paper, and soon thereafter deprives it of colour. It has scarcely any smell. Its taste is very acid, but not at all corrosive.

The hydracids, as also those which are not saturated with oxygen, act with great energy on bromic acid. The sulphurous, muriatic, hydriodic, and hydrobromic acids decompose it, as well as sulphuretted hydrogen. From hydriodic acid, compounds of brome with chlorine and iodine, result.

Bromic acid appears to be composed, in 100 parts, of 64.69 brome,
35.31 oxygen.

If it contain, like the chloric acid, 5 atoms of oxygen, the atomic weight of brome would thus be 9.1; but other experiments seem to make it 9.5; whence the acid should consist of 65.52 brome, + 34.48 oxygen.

ACID (BUTYRIC). We owe the discovery of this acid to M. Chevreul. Butter, he says, is composed of two fat bodies, analogous to those of hog's lard, of a colouring principle, and a remarkable odorous one, to which it owes the properties that distinguish it from the fats, properly so called. This principle, which he has called butyric acid, forms well characterized salts with barytes, strontian, lime, the oxides of copper, lead, &c.; 100 parts of it neutralize a quantity of base which contains about 10 of oxygen. M. Chevreul has not explained his method of separating this acid from the other constituents of butter. See *Journ. de Pharmacie*, iii. 80.

ACID (CAMPHORIC). One part of camphor being introduced into a glass retort, four parts of nitric acid sp. gr. 1.33 are to be poured on it, a receiver adapted to the retort, and all the joints well luted. The retort is then to be placed on a sand-heat, and gradually heated. During the process a considerable quantity of nitrous gas, and of carbonic acid gas, is evolved; and part of the camphor is volatilized, while another part seizes the oxygen of the nitric acid. When no more vapours are extricated, the vessels are to be separated, and the sublimed camphor added to the acid that remains in the retort. A like quantity of nitric acid is again to be poured on this, and the distillation repeated. This operation must be reiterated till the camphor is completely acidified. Twenty parts of nitric acid are sufficient to acidify one of camphor.

When the whole of the camphor is acidified, it crystallizes in the remaining liquor. The whole is then to be poured out upon a filter, and washed with distilled water, to carry off the nitric acid it may have retained. The most certain indication of the acidification of the camphor is its crystallizing on the cooling of the liquor remaining in the retort.

To purify this acid it must be dissolved in hot distilled water, and the solution, after being filtered, evaporated nearly to half, or till a slight pellicle forms; when the camphoric acid will be obtained in crystals on cooling.

Camphoric acid has a slightly acid, bitter taste, and reddens infusion of litmus.

It crystallizes; and the crystals upon the whole resemble those of muriate of ammonia. It effloresces on exposure to the atmosphere; is not very soluble in cold water; when placed on burning coals, it gives out a thick aromatic smoke, and is entirely dissipated; and with a gentle heat melts, and is sublimed. It is soluble in alcohol, and is not precipitated from it by water; a property that distinguishes it from the benzoic acid. It unites easily with the earths and alkalis. See SALTS (TABLE OF).

ACID (CAPRIC). An acid obtained by Chevreul from the soap, made with the butter of cow's milk, and so named because it has a smell like that of a goat. At 5° Fahr. it exists in the form of crystals. At 65° F. its sp. gr. is 0.910, 100 parts water dissolve only 0.12, but with alcohol, it combines in all proportions.

ACID (CAPROIC). An acid similar to the preceding, and obtained from the same source.

Its prime equivalent in the crystalline state seems to be about 11.

ACID (CARBONIC). This acid, being a compound of carbon and oxygen, may be formed by burning charcoal; but as it exists in great abundance ready formed, it is not necessary to have recourse to this expedient. All that is necessary is to pour sulphuric or muriatic acid, diluted with five or six times its weight of water, on common chalk, which is a compound of carbonic acid and lime. An effervescence ensues; carbonic acid is evolved in the state of gas, and may be received in the usual manner.

Carbonic acid abounds in great quantities in nature, and appears to be produced in a variety of circumstances. It composes $\frac{44}{100}$ of the weight of limestone, marble, calcareous spar, and other natural specimens of calcareous earth, from which it may be extricated either by the simple application of heat, or by the superior affinity of some other acid; most acids having a stronger action on bodies than this. Water, under the common pressure of the atmosphere, and at a low temperature, absorbs somewhat more than its bulk of fixed air, and then appears acidulous. If the pressure be greater, the absorption is augmented. It is to be observed, likewise, that more gas than the water *will* absorb, should be present. Heated water absorbs *less*; and if water impregnated with this acid be exposed on a brisk fire, the rapid escape of the aërial bubbles affords an appearance as if the water were at the point of boiling, when the heat is not greater than the hand can bear. Congelation separates it readily and completely from water; but no degree of cold has yet brought this acid to a state of fluidity.

Carbonic acid gas is much denser than common air, and for this reason occupies the lower parts of such mines or caverns as contain materials which afford it by decomposition. The miners call it choke-damp. The Grotto del Cano, in the kingdom of Naples, has been famous for ages on account of the effects of a stratum of fixed air which covers its bottom. It is a cave or hole in the side of a mountain, near the lake Agnano, measuring not more than eighteen feet from its entrance to the inner extremity; where if a dog or other animal that holds down its head be thrust, it is immediately killed by inhaling this noxious fluid.

Carbonic acid gas is emitted in large quantities by bodies in the state of the vinous fermentation, (see FERMENTATION); and on account of its great weight, it occupies the apparently empty space or upper part of the vessels in which the fermenting process is going on. A variety of striking experiments may be made in this stratum of elastic fluid. Lighted paper, or a candle dipped into it, is immediately extinguished; and the smoke remaining in the carbonic acid gas renders its surface visible, which may be thrown into waves by agitation like water. If a dish of water be immersed in this gas, and briskly agitated, it soon becomes impregnated, and obtains the pungent taste of Pyrmont water. In consequence of the weight of the carbonic acid gas, it may be lifted out in a pitcher, or bottle, which, if well corked, may be used to convey it to great distances, or it may be drawn out of a vessel by a cock like a liquid. The effects produced by pouring this invisible fluid from one vessel to another, have a very singular appearance: if a candle or small animal be placed in a deep vessel, the former becomes extinct, and the latter expires in a few seconds, after the carbonic acid gas is poured upon them, though the eye is incapable of distinguishing any thing that is poured. If, however, it be poured into a vessel full of air, in the sunshine, its density, being so much greater than that of the air, renders it slightly visible by the undulations and streaks it forms in this fluid, as it descends through it.

Carbonic acid reddens infusion of litmus; but the redness vanishes by exposure to the air, as the acid flies off. It has a peculiar sharp taste, which may be perceived over vats in which wine or beer is fermenting, as also in sparkling Champaign, and the brisker kinds of cider. Light passing through it is refracted by it, but does not effect any sensible alteration in it, though it appears, from experiment, that it favours the separation of its principles by other substances. It will not unite with an overdose of oxygen, of which it contains 72.72 parts in 100, the other 27.28 being pure carbon. It not only destroys life, but the heart and muscles of animals killed by it lose all their irritability, so as to be insensible to the stimulus of galvanism.

Carbonic acid is dilated by heat, but not otherwise altered by it. It is not acted upon by oxygen. Charcoal absorbs it, but gives it out again unchanged, at ordinary temperatures; but when this gaseous acid is made to traverse charcoal ignited in a tube, it is converted into carbonic oxide. Phosphorus is insoluble in carbonic acid gas; but is capable of decomposing it by compound affinity, when assisted by sufficient heat; and Priestley and Cruickshank have shown, that iron, zinc, and several other metals, are capable of producing the same effect. The inflammable air of marshes is frequently carburetted hydrogen intimately mixed with carbonic acid gas, and the sulphuretted hydrogen gas obtained from mineral waters is very often mixed with it.

Carbonic acid appears from various experiments of Ingenhousz to be of considerable utility in promoting vegetation. It is probably decomposed by the organs of plants, its base furnishing part at least of the carbon that is so abundant in the vegetable kingdom, and its oxygen contributing to replenish the atmosphere with that necessary support of life, which is continually diminished by the respiration of animals and other causes.

The most exact experiments on the neutral carbonates concur to prove, that the prime equivalent of carbonic acid is 2.75; and that it consists of one prime of carbon = 0.75 + 2.0 oxygen. This proportion is most exactly deduced from a comparison of the specific gravities of carbonic acid gas and oxygen; for it is well ascertained that the latter, by its combination with charcoal, and conversion into the former, does not change its volume. Now, 100 cubic inches of oxygen weigh 33.8 gr. and 100 cubic inches of carbonic acid 46.5, showing the weight of combined charcoal in that quantity to be 12.7. But the oxide of carbon contains only half the quantity of oxygen which carbonic acid does; and we hence infer, that the oxide of carbon consists of one prime of oxygen united to one of carbon. This *a priori* judgment is confirmed by the weight 2.75 deduced from the carbonates, as the prime equivalent of carbonic acid. Therefore we have this proportion:—

If 33.8 represent two primes of oxygen or 2; 12.7 will represent one of carbon; 33.8 : 2 : : 12.7 : 0.751, being, as above, the prime equivalent or first combining proportion of carbon. If the specific gravity of atmospheric air be called 1.0000, that of carbonic acid will be 1.5277.

We have seen that water absorbs about its volume of this acid gas, and thereby acquires a specific gravity of 1.0015. On freezing it, the gas is as completely expelled as by boiling. By artificial pressure with forcing pumps, water may be made to absorb two or three times its bulk of carbonic acid. When there is also added a little potash or soda, it becomes aërated or carbonated alkaline water, a pleasant beverage, and a not inactive remedy in several complaints, particularly dyspepsia, hiccup, and disorders of the kidneys. Alcohol condenses twice its volume of carbonic acid. The most beautiful analytical experiment with carbonic acid is the combustion of potassium in it, the formation of potash, and the deposition of charcoal. Nothing shows the power of chemical research in a more favourable light than the extraction of an invisible gas from Parian marble or crystallized spar, and its resolution by such an experiment into oxygen and carbon. From the proportions above stated, 5 gr. of potassium should be used for 3 cubic inches of gas. If less be employed, the whole gas will not be decomposed, but a part will be absorbed by the potash. From the above quantities, 3-8ths of a grain of charcoal will be obtained. If a porcelain tube, containing a coil of fine iron wire, be ignited in a furnace, and if carbonic acid be passed backwards and forwards by means of a full and empty bladder, attached to the ends of the tube, the gas will be converted into carbonic oxide, and the iron will be oxidized.

Carbonic acid gas may be rendered liquid by great pressure. Take a strong glass syphon, and seal the end of its shorter leg. By means of a long glass funnel, nearly fill that leg with strong sulphuric acid: obstruct the bended part with a bit of platinum foil, and introduce over this small pieces of carbonate of ammonia till the tube be nearly filled: now seal strongly by fusion the open end of the tube; then make the sulphuric acid to run over on the carbonate, and leave the tube inclined in such a position as that all the acid may drain out of the shorter leg. Great care must meanwhile be taken of the eyes, for the tube is very apt to explode. When the clean-drained end is afterwards placed in a mixture of ice and salt, carbonic acid in the liquid state will distil over.

Carbonic acid is a limpid, colourless body, extremely fluid, which floats upon the other contents of the tube, so that the hazardous process of distillation is hardly necessary, though this goes on rapidly at the difference of temperature between 32° and 0°. Its refractive power is much less than that of water. Its vapour exerts a pressure of 36 atmospheres at a temperature of 32°. As this liquid acid remains in contact with concentrated sulphuric acid, it may be inferred to be free from water. For this most interesting discovery, and other analogous ones on other gases, we are indebted to Mr. Faraday. *Ph. Tr.* 1823.

In point of affinity for the earths and alkalis, carbonic acid stands apparently low in the scale.

The carbonates are characterised by effervescing with almost all the acids, even the acetic, when they evolve their gaseous acid, which, passed into lime water by a tube, deprives it of its taste, and converts it into chalk and pure water.

The carbonate of barytes was, by Dr. Withering, first found native at Alston Moor in Cumberland, in 1783. From this circumstance it has been termed Witherite by Werner.

It may be prepared by exposing a solution of pure barytes to the atmosphere, when it will be covered with a pellicle of this salt by absorbing carbonic acid; or carbonic acid may be received into this solution, in which it will immediately form a copious precipitate; or a solution of nitrate or muriate of barytes may be precipitated by a solution of the carbonate of potash, soda, or ammonia. The precipitate, in either of these cases, being well washed, will be found to be very pure carbonate of barytes.

The carbonate of barytes is soluble only in 4304 times its weight of cold water, and 2304 of boiling water, and this requires a long time; but water saturated with carbonic acid dissolves 1-830th. It is not altered by exposure to the air, but is decomposed by the application of a very violent heat, either in a black lead crucible, or when formed into a paste with charcoal powder. Sulphuric acid, in a concentrated state, or diluted with three or four parts of water, does not separate the carbonic acid with effervescence, unless assisted by heat. Muriatic acid does not act upon it likewise, unless diluted with water, or assisted by heat. And nitric acid does not act upon it at all, unless diluted. It has no sensible taste, yet it is extremely poisonous.

As this salt has lately been found, in large quantities, near Murton in Cumberland, and some other places in the vicinity, it might probably be introduced into manufactures with advantage, as for extracting the bases of several salts.

It is composed of 2.75 parts of acid, and 9.75 of barytes. Its prime equivalent is therefore the sum of these numbers = 12.5.

Carbonate of strontian was first pointed out as distinct from the preceding species by Dr. Crawford, in 1790. See HEAVY SPAR.

It consists of 6.5 strontites + 2.75 carbonic acid = 9.25.

Carbonate of lime exists in great abundance in nature. It has scarcely any taste; is insoluble in pure water, but water saturated with carbonic acid takes up 1-1500th, though as the acid flies off this is precipitated. It suffers little or no alteration on exposure to the air. When heated it decrepitates, its water flies off, and lastly its acid; but this requires a pretty strong heat. By this process it is burned into lime.

It is composed of 3.5 lime + 2.75 carbonic acid = 6.25; or in 100 parts, of 56. lime and 44. acid. See CALCAREOUS SPAR and LIMESTONE.

The carbonate or *sub-carbonate of potash* was long known by the name of *vegetable alkali*.

As water at the usual temperature of the air dissolves rather more than its weight of this salt, we have thus a ready mode of detecting its adulterations in general; and as it is often of consequence in manufactures, to know how much alkali a particular specimen contains, this may be ascertained by the quantity of sulphuric acid it will saturate.

This salt is deliquescent.

It consists of 6 potash + 2.75 carbonic acid = 8.75.

The bi-carbonate of potash crystallizes, according to Fourcroy, in square prisms, the apices of which are quadrangular pyramids. According to Pelletier they are tetraëdral rhomboidal prisms, with diëdral summits. The complete crystal has eight faces, two hexagons, two rectangles, and four rhombs. It has an urinous but not caustic taste, changes the syrup of violets green: boiling water dissolves five-sixths of its weight, and cold water one-fourth; alcohol, even when hot, will not dissolve more than 1-1200th. Its specific gravity is 2.012.

When it is very pure and well crystallized it effloresces on exposure to a dry atmosphere, though it was formerly considered as deliquescent. It was thought that the common salt of tartar of the shops was a compound of this carbonate and pure potash; the latter of which, being very deliquescent, attracts the moisture of the air till the whole is dissolved. From its smooth feel, and the manner in which it was prepared, the old chemists called that solution *oil of tartar per deliquium*.

The bi-carbonate of potash melts with a gentle heat, loses its water of crystallization, amounting to $\frac{8}{100}$, and gives out one-half of its carbonic acid. To obtain the bi-carbonate we must saturate the common carbonate with carbonic acid, which is best done by passing the acid in the state of gas through a solution of the salt in twice its weight of water.

The bi-carbonate, usually called super-carbonate by the apothecaries, consists of 2 primes of carbonic acid = 5.500, 1 of potash = 6, and one of water = 1.125, in all 12.625.

The carbonate of soda has likewise been long known, and distinguished from the preceding by the name of *mineral alkali*. In commerce it is usually called *barilla*, or *soda*; in which state, however, it always contains a mixture of earthy bodies, and usually common salt. It may be purified by dissolving it in a small portion of water, filtering the solution, evaporating at a low heat, and skimming off the crystals of muriate of soda as they form on its surface. When these cease to form, the solution may be suffered to cool, and the carbonate of soda will crystallize.

It is found abundantly in nature. In Egypt, where it is collected from the surface of the earth, particularly after the desiccation of temporary lakes, it has been known from time immemorial by the name of *nitrum*, *natron*, or *natrum*. A carbonate of soda exported from Tripoli, which is called *Trona* from the name of the place where it is found, and analyzed by Klaproth, contained of soda 37 parts, carbonic acid 38, water of crystallization 22.5, sulphate of soda 2. This does not effloresce.

It crystallizes in irregular or rhomboidal decaëdrons, formed by two quadrangular pyramids, truncated very near their bases. Frequently it exhibits only rhomboidal laminæ. Its specific gravity is 1.3591. Its taste is urinous, and slightly acrid, without being caustic. It changes blue vegetable colours to a green. It is soluble in less than its weight of boiling water, and twice its weight of cold. It is one of the most efflorescent salts known, falling completely to powder in no long time. On the application of heat it is soon rendered fluid from the great quantity of its water of crystallization; but is dried by a continuance of the heat, and then melts. It is somewhat more fusible than the carbonate of potash, promotes the fusion of earths in a greater degree, and forms a glass of better quality. Like that, it is very tenacious of a certain portion of its carbonic acid. It consists in its dry state of 4 soda, + 2.75 acid, = 6.75.

But the crystals contain 10 prime proportions of water. They are composed of 22 soda, + 15.3 carbonic acid, + 62.7 water in 100 parts, or of 1 prime of soda = 4,1 of carb. acid = 2.75, and 10 of water = 11.25, in whole 18.

The bi-carbonate of soda may be prepared by saturating the solution of the preceding salt with carbonic acid gas, and then evaporating with a very gentle heat to dryness, when a white irregular saline mass is obtained. The salt is not crystallizable. Its constituents are 4 soda, + 5.50 carb. acid, +1.125 water, = 10.625; or in 100 parts 37.4 soda, + 52 acid, + 10.6 water. The intermediate native compound, the African trona, consists, according to Mr. R. Phillips, of 3 primes carbonic acid, + 2 soda, + 4 water; or in 100 parts, 38 soda, + 40 acid, + 22 water. See the article CARBONATE.

The carbonate of magnesia, in a state of imperfect saturation with the acid, has been used in medicine for some time under the simple name of magnesia. It is prepared by precipitation from the sulphate of magnesia by means of carbonate of potash. Two parts of sulphate of magnesia and one of carbonate of potash, each dissolved in its own weight of boiling water, are filtered and mixed together hot; the sulphate of potash is separated by copious washing with water; and the carbonate of magnesia is then left to drain, and afterwards spread thin on paper, and carried to the drying stove. When once dried it will be in friable white cakes, or a fine powder.

Another mode of preparing it in the great will be found under the article MAGNESIA.

The pulverulent carbonate of magnesia of the apothecary has a somewhat uncertain composition as to the proportion of acid, earth, and water. But there exists in nature a carbonated magnesia in the true equivalent proportions of 2.75 acid to 2.5 base. See MAGNESITE and DOLOMITE.

Carbonate of ammonia, when very pure, is in a crystalline form, but seldom very regular. Its crystals are so small, that it is difficult to determine their figure. The crystals commonly produced by sublimation are little bundles of needles, or very slender prisms, so arranged as to represent herborizations, fern leaves, or feathers. The taste and smell of this salt are the same with those of pure ammonia, but much weaker. It turns the colour of violets green, and that of turmeric brown. It is soluble in rather more than thrice its weight of cold water, and in its own weight of hot water; but a boiling heat volatilizes it. When pure, and thoroughly saturated, it is not perceptibly alterable in the air; but when it has an excess of ammonia, it softens and grows moist. It cannot be doubted, however, that it is soluble in air; for if left in an open vessel, it gradually diminishes in weight, and its peculiar smell is diffused to a certain distance. Heat readily sublimes, but does not decompose it.

It has been prepared by the destructive distillation of animal substances, and some others, in large iron pots, with a fire increased by degrees to a strong red heat, the aqueous liquor that first comes over being removed, that the salt might not be dissolved in it. Thus we had the *salt of hartshorn*. Thus, however, it was much contaminated by a fetid animal oil, from which it required to be subsequently purified, and is much better fabricated by mixing one part of muriate of ammonia and two of carbonate of lime, both as dry as possible, and subliming in an earthen retort.

Sir H. Davy has shown that its component parts vary, according to the manner of preparing it. The lower the temperature at which it is formed, the greater the proportion of acid and water. Thus, if formed at the temperature of 300°, it contains more than fifty per cent. of alkali; if at 60°, not more than twenty per cent.

There are indeed two or three definite compounds of carbonic acid and ammonia. The 1st is the solid sub-carbonate of the shops. It consists of 55 carbonic acid, 30 ammonia, and 15 water; or probably of 3 primes carbonic acid, 2 ammonia, and 2 water; in all 14.75 for its equivalent. 2d, M. Gay Lussac has shown, that when 100 volumes of ammoniacal gas are mixed with 50 of carbonic acid, the two gases precipitate in a solid salt, which must consist by weight of 56⅛ acid + 43⅞ alkali, being in the ratio of a prime equivalent of each. 3d, When the pungent sub-carbonate is exposed in powder to the air, it becomes scentless by the evaporation of a definite portion of its ammonia. It is then a compound of about 55 or 56 carbonic acid, 21.5 ammonia, and 22.5 water. It may be represented by 2 primes of acid, 1 of ammonia, and 2 of water, = 9.875. Another compound, it has been supposed, may be prepared by passing carbonic acid through a solution of the subcarbonate till it be saturated. This, however, may be supposed to yield the same product as the last salt. M. G. Lussac infers the neutral carbonate to consist of equal volumes of the two gases, though they will not directly combine in these proportions. This would give 18.1 to 46.5; the very proportions in the scentless salt. For 46.5 : 18.1 : : 55 : 21.42.

The first is well known as a stimulant usually put into smelling-bottles, frequently with the addition of some odoriferous oil.

The carbonate of glucine has been examined by Vauquelin, and is, among the salts of that earth, that of which he has most accurately ascertained the properties. It is in a white, dull, clotty powder, never dry, but greasy, and soft to the feel. It is not sweet like the other salts of glucine, but insipid. It is very light, insoluble in water, perfectly unalterable by the air, but very readily decomposed by fire.

Vauquelin has found, that carbonate of zircone may be formed by evaporating muriate of zircone, redissolving it in water, and precipitating by the alkaline carbonate. He also adds, that it very readily combines so as to form a triple salt, with either of the three alkaline carbonates. See Salt.

ACID (CASEIC). The name given by Proust to an acid found in cheeses, to which he ascribes their flavour.

ACID (CETIC). The name given by M. Chevreul to a supposed peculiar principle of spermaceti, which he has lately found to be the substance he has called Margarine combined with a fatty matter.

ACID (CEVADIC). By the action of potash on the fat matter of the cevadilla[*], there is obtained, in the same way as the delphinic, the cevadic acid; only as this is solid, it must be separated from the cevadate of barytes, by heating this in a retort with phosphoric acid. MM. Pelletier and Caventou discovered it. It is in the form of needles, or crystalline concretions, of a fine white colour. Its odour is analogous to that of butyric acid. 20° C. of heat are sufficient to melt it. At a temperature not much higher, it sublimes in crystalline needles. It is soluble in water, alcohol, ether; and unites to the bases, forming salts of little smell. The cevadate of ammonia gives a white precipitate with the salts of peroxide of iron. *Ann. de Chim. et de Phys.* xiv.

ACID (CHLORIC); after Acid (Muriatic).

ACID (CHLORIODIC). See Acid (Hydriodic).

ACID (CHLOROCARBONIC). See Chloride, and Chlorocarbonous Acid.

ACID (CHLOROCYANIC). See Acid (Prussic).

ACID (CHOLESTERIC). When we treat with nitric acid the fat matter of the human biliary calculi, which M. Chevreul proposed to call Cholesterine, there is formed, according to MM. Pelletier and Caventou, a peculiar acid, which they call the Cholesteric. To obtain it, they cause the cholesterine to be heated with its weight of concentrated nitric acid, by which it is speedily attacked and dissolved. There is disengaged at the same time much oxide of azote; and the liquor, on cooling, and especially on the addition of water, lets fall a yellow matter, which is the cholesteric acid impure, or impregnated with nitric acid. It may be purified by repeated washings in boiling water. However, after having washed it, it is better to effect its fusion in the midst of hot water; to add to it a small quantity of carbonate of lead; to let the whole boil for some hours, decanting and renewing the water from time to time; then to put the remaining dried mass in contact with alcohol, and to evaporate the alcoholic solution. The residuum now obtained is the purest possible cholesteric acid.

This acid has an orange-yellow colour when it is in mass; but it appears in white needles, (whose form it is difficult to determine), when we dissolve it in alcohol, and leave it to spontaneous evaporation. Its taste is very feeble, and slightly styptic; its taste resembles that of butter; and its specific gravity is intermediate between that of alcohol and water. It fuses at 58° C. and is not decomposed till the temperature be raised much above that of boiling water. It then affords oil, water, carbonic acid, and carburetted hydrogen, but no trace of ammonia. It is very soluble in alcohol, sulphuric and acetic ether, in the volatile oils of lavender, rosemary, turpentine, bergamot, &c. It is, on the other hand, insoluble in the fixed oils of olives, sweet almonds, and castor oil. It is equally so in the vegetable acids, and almost entirely insoluble in water, which takes up merely enough to make it redden litmus. Both in the cold, and with heat, nitric acid dissolves without altering it. Concentrated sulphuric acid acting on it for a considerable time, only carbonizes it.

It appears that the cholesteric acid is capable of uniting with the greater part of the salifiable bases. All the resulting salts are coloured, some yellow, others orange, and others red. The cholesterates of potash, soda, ammonia, and probably of morphia, are very soluble and deliquescent; almost all the others are insoluble, or nearly so. There is none of them which cannot be decomposed by all the mineral acids, except the carbonic, and by the greater part of the vegetable acids; so that on pouring one of these acids into a solution of the cholesterate, the cholesteric acid is instantly separated in flocks. The soluble cholesterates form precipitates in all the metallic solutions, whose base has the property of forming an insoluble or slightly soluble salt with cholesteric acid.

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[*] Cevadilla, petite orge (hordeolum), a plant, according to Haller, belonging to the class of delphinium and aconite. It comes from Senegal. There is another called Cevadilla Americana, which is corrosive.

MM. Pelletier and Caventou found the cholesterate of barytes to consist of 100 of acid, and 56.259 base; whence the prime equivalent of the former appears to be about 17.35. Yet they observed, on the other hand, that on treating the cholesterate of lead with sulphuric acid, they obtained as much sulphate of lead as of cholesterate. From this experiment, the equivalent of the dry acid would seem to be 5; hence we may imagine, that when the cholesteric acid unites to the oxide of lead, and in general to all the oxides which have a slight affinity for oxygen, there takes place something similar to what happens in the reaction of oxide of lead and oxalic acid. *Journ. de Pharm.* iii. 292.

ACID (CHROMIC). This acid was at first extracted from the red lead ore of Siberia, by treating this ore with carbonate of potash, and separating the alkali by means of a more powerful acid. In this state it is impure, forming a red or orange-coloured powder, of a peculiar rough metallic taste. If this powder be exposed to the action of light and heat, it loses its acidity, and is converted into green oxide of chrome, giving out pure oxygen gas.

To obtain pure chromic acid, we must distil fluor spar, chromate of lead (the yellow pigment), and sulphuric acid (anhydrous?) in a leaden retort, when a gaseous mixture of chromic and fluoric acids is evolved, that is readily absorbable by water. This mixed gas affords a thick orange smoke, and on coming in contact with air deposits small red crystals of chromic acid. Ammoniacal gas introduced into this gas, contained in glass jars lined with resin, burns with explosion. Crystals of chromic acid are also decomposed in ammoniacal gas with a flash of light, and become protoxide of chromium. Water, by absorbing this mixed gas, acquires an orange tint; from which, by evaporation, pure chromic acid is obtained, the fluoric being volatilized. If the gas be received in a deep and moistened platinum vessel, it descends, saturates the water, and is then entirely absorbed by the fluoric acid, which is at length dissipated, the vessel becoming filled with a red snow, consisting of chromic acid. This crystalline matter, when heated to redness in a platinum dish, fuses, explodes with a flash, and resolves itself into protoxide and oxygen. The crystals obtained from the water do not present this phenomenon.

The chromic acid is soluble in water, and crystallizes, by cooling and evaporation, in longish prisms of a ruby red. Its taste is acrid and styptic. Its specific gravity is not exactly known; but it always exceeds that of water. It powerfully reddens the tincture of turnsole.

Its action on combustible substances is little known. If it be strongly heated with charcoal, it grows black, and passes to the metallic state without melting.

Of the acids, the action of the muriatic on it is the most remarkable. If this be distilled with the chromic acid, by a gentle heat, it is readily converted into chlorine. It likewise imparts to it by mixture the property of dissolving gold; in which the chromic resembles the nitric acid. This is owing to the weak adhesion of its oxygen, and it is the only one of the metallic acids that possesses this property.

The extraction of chromic acid from Chrome ore is performed by igniting it with its own weight of nitre in a crucible. The residue is lixiviated with water, which being then filtered, contains the chromate of potash. On pouring into this a little nitric acid and muriate of barytes, an instantaneous precipitate of the chromate of barytes takes place. After having procured a certain quantity of this salt, it must be put in its moist state into a capsule, and dissolved in the smallest possible quantity of weak nitric acid. The barytes is to be then precipitated by very dilute sulphuric acid, taking care not to add an excess of it. When the liquid is found by trial to contain neither sulphuric acid nor barytes, it must be filtered. It now consists of water, with nitric and chromic acids. The whole is to be evaporated to dryness, conducting the heat at the end so as not to endanger the decomposition of the chromic acid, which will remain in the capsule under the form of a reddish matter. It must be kept in a glass phial well corked.

Chromic acid, heated with a powerful acid, becomes chromic oxide; while the latter, heated with the hydrate of an alkali, becomes chromic acid. As the solution of the oxide is green, and that of the acid yellow, these transmutations become very remarkable to the eye. From Berzelius's experiments on the combinations of the chromic acid with barytes, and oxide of lead, its prime equivalent seems to be 6.5; consisting of 3.5 chromium, and 3.0 oxygen. See CHROMIUM.

It readily unites with alkalis, and is the only acid that has the property of colouring its salts, whence the name of chromic has been given it.

Chromate of potash is obtained from the ferriferous chrome ore, by igniting it with nitre, as described above. By careful evaporation it may be obtained in crystals, the usual form of which is four-sided prisms terminated by dihedral summits, or oblique four-sided prisms, terminated by four-sided pyramids. Their colour is bright yellow. Their taste is cooling and disagreeable. Water at 60° dissolves about half its weight of this salt, and boiling water much more. It is insoluble in alcohol. Its specific gravity is 2.6. Heat causes the salt to assume a transient red tint, which passes into yellow on cooling. It contains no water of crystallization. Its constituents are chromic acid 6.5, potash 6 = 12.5.

Bichromate of potash is easily formed, by adding to a saturated solution of the yellow chromate some dilute nitric acid. On heating the mixture, the orange precipitate, which ensues on the addition of the nitric acid, is dissolved, and by slow cooling, fine crystals of bichromate may be obtained. Their form is that of square tables with bevelled edges, or flat four-sided prisms. They are permanent in the air. Their taste is metallic and bitter. Water at 60° dissolves about one-tenth of this salt; but boiling water dissolves nearly half its weight. It is not soluble in alcohol. Its sp. gr. is 1.98. It is anhydrous. It consists of chromic acid 13, potash 6 = 19.

The chromate of barytes is very little soluble.

If the chromic acid be mixed with filings of tin and the muriatic acid, it becomes at first yellowish brown, and afterwards assumes a bluish-green colour, which preserves the same shade after desiccation. Ether alone gives it the same dark colour. With a solution of nitrate of mercury, it gives a precipitate of a dark cinnabar colour. With a solution of nitrate of silver it gives a precipitate, which, the moment it is formed, appears of a beautiful carmine colour, but becomes purple by exposure to the light.

With nitrate of copper it gives a chesnut-red precipitate. With the solution of sulphate of zinc, muriate of bismuth, muriate of antimony, nitrate of nickel, and muriate of platina, it produces yellowish precipitates, when the solutions do not contain an excess of acid. With muriate of gold it produces a greenish precipitate.

When melted with borax, or glass, or acid of phosphorus, it communicates to it a beautiful emerald-green colour.

If paper be impregnated with it, and exposed to the sun a few days, it acquires a green colour, which remains permanent in the dark.

A slip of iron, or tin, put into its solution, imparts to it the same colour.

The aqueous solution of tannin produces a flocculent precipitate of a brown fawn colour. See SALT.

ACID (CITRIC). To procure this acid, boiling lemon-juice is to be saturated with powdered chalk, the weight of which is to be noted, and the powder must be stirred up from the bottom, or the vessel shaken from time to time. The neutral saline compound falls to the bottom, while the mucilage remains suspended in the watery fluid, which must be decanted off; the remaining precipitate must then be washed with warm water until it comes off clear. To the powder thus edulcorated, a quantity of sulphuric acid, equal the chalk in weight, and diluted with ten parts of water, must be added, and the mixture boiled a few minutes. The sulphuric acid combines with the earth, and forms sulphate of lime, which remains when the cold liquor is filtered, while the disengaged acid of lemons remains dissolved in the fluid. This last must be evaporated to the consistence of a thin syrup, which yields the pure citric acid in little needle-like crystals. It is necessary that the sulphuric acid should be rather in excess, because the presence of a small quantity of lime will prevent the crystallization.

To have it perfectly pure, it must be repeatedly crystallized, and thus it forms very large and accurately defined crystals in rhomboidal prisms, the sides of which are inclined in angles of 60° and 120°, terminated at each end by tetraëdral summits, which intercept the solid angles.

Its taste is extremely sharp, so as to appear caustic. It is among the vegetable acids the one which most powerfully resists decomposition by fire.

In a dry and warm air it seems to effloresce; but it absorbs moisture when the air is damp, and at length loses its crystalline form. A hundred parts of this acid are soluble in seventy-five of water at 60°, according to Vauquelin. Though it is less alterable than most other solutions of vegetable acids, it will undergo decomposition when long kept.

The crystals of citric acid, according to Berzelius, contain 79 *per cent.* of real acid. The rest is water. The same chemist found, from citrate of lead that the prime equivalent of the crystals was 9.5, while that of the real acid was 7.368; and its constituents were oxygen 54.831, carbon 41.369, hydrogen 3.800. My own experiments on citric acid led me to conclude that its prime equivalent in the crystalline state was 8.375; and that it consisted of oxygen 59.7, carbon 35.8, and hydrogen 4.5. Two atoms of oxygen and two of hydrogen separate when citric acid is combined with oxide of lead in what is called the dry citrate of this metal. The prime equivalent of the acid in this state becomes 6.125. Vauquelin found that 36 parts of crystallized citric acid took for saturation 61 of bicarbonate of potash. Hence, the prime equivalent of such acid is 7.45; between which, and the number given by Berzelius, mine is nearly the mean. Vauquelin's result differs widely from the atomic weight adopted by the Swedish chemist.

If a solution of barytes be added gradually to a solution of citric acid, a flocculent precipitate is formed, soluble by agitation, till the whole of the acid is saturated. This salt at first falls down in powder, and then collects in silky tufts, and a kind of very beautiful and shining silvery bushes. It requires a large quantity of water to dissolve it.

The citrate of lime has been mentioned already, in treating of the mode of purifying the acid.

The citrate of potash is very soluble and deliquescent.

The citrate of soda has a dull saline taste; dissolves in less than twice its weight of water; crystallizes in six-sided prisms with flat summits; effloresces slightly, but does not fall to powder; boils up, swells, and is reduced to a coal on the fire.

Citrate of ammonia is very soluble; does not crystallize unless its solution be greatly concentrated; and forms elongated prisms.

Citrate of magnesia does not crystallize.

The affinities of the citric acid are arranged by Vauquelin in the following order: barytes, lime, potash, soda, strontian, magnesia, ammonia, alumina.

The citric acid is found in many fruits united with the malic acid; which see, for the process of separating them in this case.

Citric acid being more costly than tartaric, may be occasionally adulterated with it. This fraud is discovered, by adding slowly to the acid dissolved in water a solution of carbonate of potash, which will give a white pulverulent precipitate of tartar, if the citric be contaminated with the tartaric acid. When one part of citric acid is dissolved in 19 of water, the solution may be used as a substitute for lemon-juice. If before solution the crystals be triturated with a little sugar and a few drops of the oil of lemons, the resemblance to the native juice will be complete. It is an antidote against sea scurvy; but the admixture of mucilage and other vegetable matter in the recent fruit of the lemon, has been supposed to render it preferable to the pure acid of the chemist. See SALT.

ACID (COLUMBIC). The experiments of Mr. Hatchett have proved, that a peculiar mineral from Massachusetts, deposited in the British Museum, consisted of one part of oxide of iron, and somewhat more than three parts of a white-coloured substance, possessing the properties of an acid. Its basis was metallic. Hence he named this Columbium, and the acid the Columbic. Dr. Wollaston, by very exact analytical comparisons, proved, that the acid of Mr. Hatchett was the oxide of the metal lately discovered in Sweden by Mr. Ekeberg, in the mineral yttrotantalite, and thence called tantalum. Dr. Wollaston's method of separating the acid from the mineral is peculiarly elegant. One part of tantalite, five parts of carbonate of potash, and two parts of borax, are fused together in a platina crucible. The mass, after being softened in water, is acted on by muriatic acid. The iron and manganese dissolve, while the columbic acid remains at the bottom. It is in the form of a white powder, which is insoluble in nitric and sulphuric acids, but partially in muriatic. It forms with barytes an insoluble salt, of which the proportions, according to Berzelius, are 24.4 acid, and 9.75 barytes. By oxidizing a portion of the revived tantalum or columbium, Berzelius concludes the composition of the acid to be 100 metal and 5.485 oxygen.

ACID (CROCONIC). When potassium is prepared from calcined tartar by Brunner's method, a gas is evolved which deposits a greyish-brown substance on cold bodies. This substance, with a little water, is separated into two parts; one very soluble, yielding a brownish-yellow liquid, which spontaneously concentrated, furnishes an acicular orange-coloured salt. This salt, purified by repeated crystallization, has been called by M. Gmelin *croconate* of potash, because it contains a yellow acid, which yields many combinations of the same colour.

Croconate of potash is neutral, inodorous, having a weak taste like that of nitre. Its primitive form is a rhomboid of 106° and 74°. Croconic acid is obtained by treating this salt with absolute alcohol, to which a little sulphuric acid has been added; sulphate of potash is formed and the CROCONIC ACID is dissolved. It crystallizes in grains or needles; is transparent, of a fine yellow colour, inodorous, of a rough acid taste, and reddens litmus. M. Gmelin thinks that this acid is a hydracid like the prussic. Hydrocroconic acid consists of carbon 23.23, hydrogen 0.77, oxygen 24.81, water 13.98, which in the salt of potash are united with 37.21 of that alkali.

ACID (CYANIC). See ACID (PRUSSIC).

ACID (DELPHINIC). The name given by M. Chevreul to a substance which he has extracted from the oil of the dolphin. It resembles a volatile oil; has a light lemon colour, and a strong aromatic odour, analogous to that of rancid butter. Its taste is pungent, and its vapour has a sweetened taste of ether. Its density at 14° C. is 0.941. It is slightly soluble in water, and very soluble in alcohol. The latter solution strongly reddens litmus. 100 parts of delphinic acid neutralize a quantity of base which contains 9 of oxygen, whence its prime equivalent appears to be 11.11.—*Annales de Chim. et de Phys.* vii.

ACID (ELLAGIC). The deposit which forms in infusion of nut-galls left to itself is not composed solely of gallic acid and a matter which colours it. It contains besides a little gallate and sulphate of lime, and a new acid, which was pointed out for the first time by M. Chevreul in 1815, an acid on which M. Braconnot made observations in 1818, and which he proposed to call acid *ellagic*, from the word *galle* reversed. Pobably this acid does not exist ready formed in nut-galls. It is insoluble; and carrying down with it the greater part of the gallic acid, forms the yellowish crystalline deposit. But boiling water removes the gallic acid from the ellagic; whence the means of separating them from one another.—*Ann. de Chim. et de Phys.* ix. 181.

ACID (FLUORIC). The powder of crystallized fluor spar is to be put into a silver or leaden alembic, and its own weight of sulphuric acid poured over it. Adapt to the alembic a silver or leaden tube terminating in a receiver of the same metal, surrounded by ice. On applying a moderate heat to the alembic, the fluoric acid will rise in vapours, which will condense in the receiver into an intensely active liquid, first procured by M. Gay Lussac; and since examined by Sir H. Davy.

It has the appearance of sulphuric acid, but is much more volatile, and sends off white fumes when exposed to air. Its specific gravity is only 1.0609. It must be examined with great caution, for when applied to the skin it instantly disorganises it, and produces very painful wounds. When potassium is introduced into it, it acts with intense energy, and produces hydrogen gas and a neutral salt; when lime is made to act upon it, there is a violent heat excited, water is formed, and the same substance as fluor spar is produced. With water in a certain proportion, its density increases to 1.25. When it is dropped into water, a hissing noise is produced with much heat, and an acid fluid not disagreeable to the taste is formed if the water be in sufficient quantity. It instantly corrodes and dissolves glass.

In order to insure the absolute purity of the acid, the first portions that come over may be set apart as possibly containing some silicated fluoric acid, if any silica was present in the spar.

Considerable difference of opinion prevails concerning the prime equivalent of this acid, as it exists in its dry combinations. Sir H. Davy states, that 100 fluor spar yield 175.2 sulphate of lime; whence we deduce the prime equivalent of fluoric acid to be 1.35, to lime 3.5, and oxygen 1.00. Berzelius, in his last series of experiments, gives from fluate of lime 1.357, for the equivalent of fluoric acid.

Of all the fluates which he analysed, that of lime was the only one which he succeeded in freeing perfectly from the last portions of silica; and hence he regards the above result as quite satisfactory. In three experiments, in which he saturated carbonate of lime with pure fluoric acid, evaporated to dryness and ignited, he obtained from 100 parts of such fluate, on decomposing it by sulphuric acid, 174.9, 175, and 175.12 of ignited sulphate of lime. *Annales de Chim. et de Phys.* 1824. This accordance between Sir H. Davy's result with the native fluate, and that of Berzelius with the artificial, seems decisive.

Berzelius observes that fluate of lime can be prepared only by saturating the recently precipitated moist carbonate with pure fluoric acid. The fluate is thus obtained as granular as the carbonate, and may be washed; whereas, if prepared by double decomposition, we obtain a jelly which does not change even by evaporation, and which cannot be washed.

Dr. Thomson, in his elaborate work on the first principles of Chemistry, assigns 1.25 as the prime equivalent of fluoric acid. He deduced this number from the quantity of chloride of calcium, and of chloride of barium, to which a certain weight of fluate of soda was found to be equivalent in the way of double decomposition. But his fluate of soda was prepared in a very questionable manner; by adding carbonate of soda in small quantities to a solution of carbonate of ammonia, previously saturated with silicated fluoric gas; evaporating the whole to dryness; redissolving and evaporating till the fluate of soda crystallized in transparent crusts. As a fluosilicate of ammonia exists, possibly some of this may have been formed, of which some silica might remain associated with his soda. Nor does his fluate of soda correspond in character to the description of this salt directly formed by Berzelius, by saturating carbonate of soda with pure fluoric acid. By spontaneous evaporation, fluate of soda is obtained in transparent cubes, or regular octahedrons; by heat, in groups of small cubical grains. It contains no water of crystallization, and is more difficult of fusion by heat than glass. At the temperature of 60° F. 100 parts of water dissolve only 4.8 parts of it; and at the boiling point only 4.3. Dr. Thomson says, that he dissolved 5.25 grains of his salt (white crusts, freed by ignition from their *water of crystallization*) in a *little* water. From the mode of preparing his primary salt, from its appearance, and from the defect in the process of double decomposition for forming pure fluate of lime, Dr. Thomson's atomic number seems entitled to little confidence.

Fluoric acid may either be regarded as a compound of oxygen with an unknown base to be called fluor; or of hydrogen with an electro-negative element to be called fluorine. If fluor spar consist of lime associated with an oxygen acid, then this will contain one prime proportion of oxygen = 1, combined with one prime of fluor = 0.357. Were this latter number 0.375, to which it approaches, it would equal the weight of three atoms of hydrogen. But if fluor spar be truly a fluoride of calcium, then, from its prime equivalent 4.857, we deduct the prime equivalent of calcium 2.5, and the remainder 2.357 will be the prime of fluorine, a number nearly 19 times that of hydrogen.

From the remarkable property possessed by fluoric acid, of dissolving silica, it has been employed for etching on glass, both in the gaseous state and combined with water. The glass is previously coated with white bees' wax;

on which the figures are traced with a sharp point.

With the view of separating its hydrogen, Sir H. Davy applied the power of the great voltaic batteries of the Royal Institution to the liquid fluoric acid. "In this case, gas appeared to be produced from both the negative and positive surfaces; but it was probably only the undecompounded acid rendered gaseous, which was evolved at the positive surface; for during the operation the fluid became very hot, and speedily diminished."—"In the course of these investigations I made several attempts to detach hydrogen from the liquid fluoric acid, by the agency of oxygen and chlorine. It was not decomposed when passed through a platina tube heated red-hot with chlorine, nor by being distilled from salts containing abundance of oxygen, or those containing abundance of chlorine."

The marvellous activity of fluoric acid may be inferred from the following remarks of Sir H. Davy, from which also may be estimated in some measure the prodigious difficulty attending refined investigations on this extraordinary substance.

"I undertook the experiment of electrizing pure liquid fluoric acid with considerable interest, as it seemed to offer the most probable method of ascertaining its real nature; but considerable difficulties occurred in executing the process. The liquid fluoric acid immediately destroys glass, and all animal and vegetable substances; it acts on all bodies containing metallic oxides; and I know of no substances which are not rapidly dissolved or decomposed by it, except metals, charcoal, phosphorus, sulphur, and certain combinations of chlorine. I attempted to make tubes of sulphur, of muriates of lead, and of copper containing metallic wires, by which it might be electrized, but without success. I succeeded, however, in boring a piece of horn silver in such a manner that I was able to cement a platina wire into it by means of a spirit lamp; and by inverting this in a tray of platina, filled with liquid fluoric acid, I contrived to submit the fluid to the agency of electricity in such a manner, that, in successive experiments, it was possible to collect any elastic fluid that might be produced. Operating in this way with a very weak voltaic power, and keeping the apparatus cool by a freezing mixture, I ascertained that the platina wire at the positive pole rapidly corroded, and became covered with a chocolate powder; gaseous matter separated at the negative pole, which I could never obtain in sufficient quantities to analyze with accuracy, but it inflamed like hydrogen. No other inflammable matter was produced when the acid was pure." We beg to refer the reader to the Philosophical Transactions for 1813 and 1814; or the 42d and 43d vols. of Tilloch's Magazine, where he will see philosophical sagacity and experimental skill in their utmost variety and vigour, struggling with the most mysterious and intractable powers of matter.

The salts formed by fluoric acid and several bases have been lately examined by M. Berzelius with his accustomed precision.

Superfluate of potash. This acid fluate is obtained by mixing with the acid a quantity of potash, insufficient to saturate it. On concentrating the solution, a little of the redundant acid flies off, but the greater part remains and crystallizes with the alkali. This salt when heated fuses and leaves 74.9 *per cent.* of neutral fluate, while fumes of fluoric acid are volatilized. Berzelius regards the above acid salt, as composed of an atom of fluate of potash, and an atom of hydrated fluoric acid.

Fluate of potash is prepared by saturating imperfectly fluoric acid with carbonate of potash, evaporating and heating so as to expel the excess of acid. It has a sharp saline taste, is very alkaline, and deliquesces in the air. It crystallizes very difficultly in water, and then forms cubes or rectangular prisms, with stair-like scales, similar to common salt.

Acid fluate of soda. This salt is little soluble in cold water. By a slow spontaneous evaporation it affords rhomboidal crystals, having a sharp taste, and distinctly acid. Heat separates the fluoric acid in a concentrated state, without changing the form of the crystals, and 68.1 *per cent.* of neutral fluate remain. Berzelius considers this salt to be a compound of an atom of fluate of soda, and an atom of hydrated fluoric acid.

Neutral fluate of soda. This salt may be obtained directly from fluoric acid and carbonate of soda, or by decomposing 100 parts of the double fluate of soda and silica, by 112 parts of dried carbonate of soda. When the salt is pure, and left to spontaneous evaporation, it affords transparent cubes of regular octohedrons, which often present a pearly lustre. Octohedrons are always obtained when the solution contains some carbonate of soda, but on the contrary, groups of small cubic grains when the evaporation is produced by elevation of temperature. The fluates of potash and soda are isomorphous with the muriates of the same bases. Fluate of soda melts with more difficulty than glass. 100 parts of water at 60° F. dissolve 4.8 of it; and at the boiling point only 4.3.

Acid fluate of ammonia, forms small granular crystals, which deliquesce.

Neutral fluate of ammonia, is more volatile than sal ammoniac. It is easily obtained by heating one part of dry sal ammoniac with a little more than two parts of fluate of soda in a crucible of platinum with its lid turned upwards. Into this lid a little cold water is put, while the bottom of the crucible is heated with a spirit of wine lamp. The fluate of ammonia thus sublimes perfectly pure in a mass of small prismatic crystals. It fuses before subliming, and acts on glass even in its dry state, and at ordinary temperatures.

The earthy fluates are best prepared by digesting their recently precipitated moist carbonates in an excess of fluoric acid. That of barytes is slightly soluble in water, and readily in muriatic acid.

ACID (*FLUO*-SILICIC). If instead of being distilled in metallic vessels, the mixture of fluor spar and oil of vitriol be distilled in glass vessels, little of the corrosive liquid will be obtained; but the glass will be acted upon, and a peculiar gaseous substance will be produced, which must be collected over mercury. The best mode of procuring this gaseous body is to mix the fluor spar with pounded glass or quartz; and in this case, the glass retort may be preserved from corrosion, and the gas obtained in greater quantities. This gas, which is called silicated fluoric gas, is possessed of very extraordinary properties.

It is very heavy; 100 cubic inches of it weigh 110.77 gr. and hence its sp. gr. is to that of air, as 3.632 is to 1.000. It is about 48 times denser than hydrogen. When brought into contact with water, it instantly deposits a white gelatinous substance, which is hydrate of silica; it produces white fumes when suffered to pass into the atmosphere. It is not affected by any of the common combustible bodies; but when potassium is strongly heated in it, it takes fire and burns with a deep red light; the gas is absorbed, and a fawn-coloured substance is formed, which yields alkali to water with slight effervescence, and contains a combustible body. The washings afford potash, and a salt, from which the strong acid fluid previously described, may be separated by sulphuric acid.

The gas formed by the action of liquid sulphuric acid on a mixture containing silica and fluor spar, the silicated fluoric gas or fluosilicic acid, may be regarded as a compound of fluoric acid and silica. It affords, when decomposed by solution of ammonia, 61.4 per cent. of silica; and hence was at first supposed by Sir *H. Davy* to consist of two prime proportions of acid = 2.652, and one of silica = 4.066, the sum of which numbers might represent its equivalent = 6.718. One volume of it condenses two volumes of ammonia, and they form together a peculiar saline substance which is decomposed by water. The composition of this salt is easily reconciled to the numbers given as representing silica and fluoric acid, on the supposition that it contains one prime of ammonia to one of the fluosilicic gas; for 200 cubic inches of ammonia weigh 36.2 gr. and 100 of the acid gas 110.77. Now 36.2 : 2.125 : : 110.77 : 652.125.

Dr. John Davy obtained, by exposing that gas to the action of water, $\frac{148}{1000}$ of its weight of silica; and from the action of water of ammonia he separated $\frac{614}{1000}$ of its weight. Hence 100 cubic inches consist by weight of 68 silica and 42 of unknown fluoric matter, the gas which holds the silica in solution. Sir H. Davy, however, latterly, conceives that this gas is a compound of the bases of silica, or silicon, with fluorine, the supposed basis of fluoric acid.

Berzelius, in his late elaborate researches on the fluoric combinations (*Annales de Chim. et de Phys.* 27. *p.* 289) says that the silicated fluoric acid should be regarded as nothing else than fluate of silica, for it is only with the neutral fluates that it can unite without suffering decomposition; and that when a portion of silica has been separated from it, it can be replaced only by an alkali, an oxide, or water. When he put silicated fluoric gas in contact with carbonate of potash or soda, reduced to a very fine powder, there was no more of it absorbed than what might be ascribed to moisture contained in the carbonate, and the salt, after exposure to the gas for several days, had absorbed but an extremely small portion of it. The same result is observed with pure lime and the bicarbonate of potash. But the gas is very easily absorbed when exposed, even without moisture, to a finely pulverized fluate, either with an alkaline, earthy, or metallic base. At the end of a few hours, the fluate is completely saturated with the gas; showing that the portion of fluoric acid and silica absorbed, has no need of any new base for its saturation. This simple fact shows that the pretended fluosilicates, instead of being combinations of a fluate with a silicate, are rather combinations of fluate of silica with fluates of the other bases. M. Berzelius infers from his experiments that fluate of silica is formed of 100 parts fluoric acid and 144.5 silica. Water separates one third of this silica.

ACID (FLUO-BORIC). If, instead of glass or silica, the fluor spar be mixed with dry vitreous boracic acid, and distilled in a glass vessel with sulphuric acid, the proportions being one part boracic acid, two fluor spar, and twelve oil of vitriol, the gaseous substance formed is of a different kind, and is called the fluoboric gas. 100 cubic inches of it weigh 73.5 gr. according to Sir H. Davy, which makes its density be to that of air as 2.41 is to 1.00; but Dr. John Davy states its density to that of air as 2.371 to 1.000. It is colourless; its smell is pungent, and resembles that of muriatic acid; it cannot be breathed without suffocation; it extinguishes combustion; and reddens strongly the tincture of turnsole. It has no manner of action on glass, but a very powerful one on vegetable and animal matter: it attacks them with as much force as concentrated sulphuric acid, and appears to operate on these bodies by the production of water; for while it carbonizes them, or evolves carbon, they may be touched without any risk of burning. Exposed to a high temperature, it is not decomposed; it is condensed by cold without changing its form. When it is put in contact with oxygen, or air, either at a high or low temperature, it experiences no change, except seizing, at ordinary temperatures, the moisture which these gases contain. It becomes in consequence a liquid which emits extremely dense vapours. It operates in the same way with all the gases which contain hygrometric water. However little they may contain, it occasions in them very perceptible vapours. It may hence be employed with advantage to show whether or not a gas contains moisture.

No combustible body, simple or compound, attacks fluoboric gas, if we except the alkaline metals. Potassium and sodium, with the aid of heat, burn in this gas, almost as brilliantly as in oxygen. Boron and fluate of potash are the products of this decomposition. It might hence be inferred, that the metal seizes the oxygen of the boracic acid, sets the boron at liberty, and is itself oxidized and combined with the fluoric acid. According to Sir H. Davy's views, the fluoboric gas being a compound of fluorine and boron, the potassium unites to the former, giving rise to the fluoride of potassium, while the boron remains disengaged.

Fluoboric gas is very soluble in water. Dr. John Davy says, water can combine with 700 times its own volume, or twice its weight at the ordinary temperature and pressure of the air. The liquid has a specific gravity of 1.770. If a bottle containing this gas be uncorked under water, the liquid will rush in and fill it with explosive violence. Water saturated with this gas is limpid, fuming, and very caustic. By heat about one-fifth of the absorbed gas may be expelled; but it is impossible to abstract more. It then resembles concentrated sulphuric acid, and boils at a temperature considerably above 212°. It afterwards condenses altogether, in *striæ*, although it contains still a very large quantity of gas. It unites with the bases, forming salts, called fluoborates, none of which has been applied to any use. The most important will be stated under the article Salt.

The 2d part of the Phil. Transactions for 1812, contains an excellent paper by Dr. John Davy on fluosilicic and fluoboric gases, and the combinations of the latter with ammoniacal gas. When united in equal volumes, a pulverulent salt is formed; a second volume of ammonia, however, gives a liquid compound; and a third of ammonia, which is the limit of combination, affords still a liquid; both of them curious on many accounts. "They are," says he, "the first salts that have been observed liquid at the common temperature of the atmosphere. And they are additional facts in support of the doctrine of definite proportions, and of the relation of volumes."

ACID (FLUO-TANTALIC). This acid is prepared in a similar way to the following; and forms, with the bases, salts called *fluo-tantalates*.

ACID (FLUO-TITANIC). When fluoric acid is poured on titanic acid, the latter becomes warm, even after having been previously ignited, and dissolves completely with the aid of heat. Evaporated at a gentle heat to the consistence of syrup, the solution affords crystals, which do not re-dissolve completely in water, but which are decomposed into two peculiar combinations, of which one is acidulous and soluble, and the other with excess of base is insoluble. The solution of the former, namely of the fluo-titanic acid, in water, is analogous to the liquid fluosilicic acid; it contains fluo-titanic acid, and fluoric acid combined with water. The water may be replaced by other bases, and in this way may be formed a series of salts which M. Berzelius calls *fluo-titanates*. *The fluo-titanate of potash* crystallizes in brilliant scales like boracic acid, which re-dissolve in water without decomposition. It consists in 100 parts of potash 38.7, titanic acid 35, and fluoric acid 26.3.

ACIDS (FERROPRUSSIC and FERRURETTED CHYAZIC). See Acid (Prussic).

ACID (FORMIC). To procure pure formic acid, Gehlen saturates the expressed liquor of ants with subcarbonate of potash, pours into the compound sulphated peroxide of iron, filters, evaporates to the consistence of syrup, and distils in a glass retort, with a sufficient quantity of sulphuric acid. The product which passes into the receiver is very sour, and without any perceptible odour of sulphurous acid. He then puts it in contact with carbonate of copper, evaporates the solution, and procures fine blue crystals, which he considers as formiate of copper. From this he extracts the pure and the most concentrated acid possible, by decomposing the salt with two-thirds of its weight of sulphuric acid, aided by heat, distilling it into a receiver, and rectifying by a second distillation. From 13 ounces of formiate thus treated, he obtained more than six ounces and a half of pure formic acid.

This acid has a very sour taste, and continues liquid even at very low temperatures. Its specific gravity is 1.1168 at 68°, which is much denser than acetic acid ever is. Berzelius finds, that the formiate of lead consists of 4.696 acid, and 14 oxide of lead; and that the ultimate constituents of the dry acid are hydrogen 2.84 + carbon 32.40 + oxygen 64.76 = 100.

M. Dobereiner has recently succeeded (See Gilbert's Annales, xi. 107.) in forming this acid artificially. When a mixture of tartaric acid, or of cream of tartar, black oxide of manganese, and water, is heated, a tumultuous action ensues, carbonic acid is evolved, and a liquid acid distils over, which, on superficial examination, was mistaken for acetic acid, but which now proves to be formic acid. This acid, mixed with concentrated sulphuric acid, is at common temperatures converted into water and carbonic oxide; nitrate of silver or of mercury converts it, when gently heated, into carbonic acid, the oxides being at the same time reduced to the metallic state. With barytes, oxide of lead, and oxide of copper, it produces compounds, having all the properties of the genuine formiates of these metals. If a portion of sulphuric acid be employed in the above process, the tartaric acid is resolved entirely into carbonic acid, water, and formic acid; and the product of the latter is much increased. The best proportions are, two parts tartaric acid, five peroxide of manganese, and five sulphuric acid diluted with about twice its weight of water.

M. Dobereiner finds that when formic acid is decomposed by sulphuric acid, it is resolved into 23.3 water, and 75.7 carbonic oxide in 100 parts; or of one volume of vapour of water, and two volumes carbonic oxide gas; or two atoms carbon, three oxygen, and one hydrogen.

ACID (FULMINIC). Put 6.5 parts of nitric acid, sp. gravity 1.36 or 1.38, into a pint matrass, and a piece of coin, containing nearly 35 parts of pure silver. Pour the resulting solution into about 927 parts of strong alkohol, and heat to ebullition. On the appearance of turbidness, remove from the fire, and add by degrees an equal quantity of alkohol to the solution, in order to moderate the ebullition, and to cool it. Filter it when cold, and wash away the whole free acid. The fulminate of silver is now pure and white as snow. Dry it in a steam heat for 2 or 3 hours, after which it will be found to equal in weight the silver employed. A slight blow between hard bodies explodes it. It may be analyzed by rubbing it with the finger with 40 times its weight of peroxide of copper, and igniting the mixture in a glass tube. 100 parts of it, analyzed in this way, afforded 77.528 of oxide of silver. The acid, associated with this oxide, is the cyanic. Hence the ultimate constituents are in 100 parts: silver, 72.187; oxygen, 5.341; cyanogen, 17.16; oxygen (combined with the silver), 5,312. It consists, therefore, of 1 atom oxide of silver, 14.75; 2 atoms cyanogen, 6.5; 2 oxygen, 2 = 23.25.

To prepare alkaline fulminates, chlorides should be used. Thus to obtain the double fulminate of silver and potash, decompose the fulminate of silver by chloride of potassium; being careful to add no more of the chloride than is sufficient to precipitate rather less than half the silver. The solution will contain the double fulminate. *Liebeg & Gay Lussac, Annales de Chim. et Phys.* xxv. 285.

ACID (FUNGIC). The expressed juice of the *boletus juglandis*, *boletus pseudoigniarius*, the *phallus impudicus*, *merulius cantharellus*, or the *peziza nigra*, being boiled to coagulate the albumen, then filtered, evaporated to the consistence of an extract, and acted on by pure alcohol, leaves a substance which has been called by Braconnot *Fungic Acid.* He dissolved that residue in water, added solution of acetate of lead, whence resulted *fungate of lead*, which he decomposed at a gentle heat by dilute sulphuric acid. The evolved fungic acid being saturated with ammonia, yielded a crystallized fungate of ammonia, which he purified by repeated solution and crystallization. From this salt by acetate of lead, and thereafter sulphuric acid as above detailed, he procured the pure fungic acid.

It is a colourless, uncrystallizable, and deliquescent mass, of a very sour taste. The fungates of potash and soda are uncrystallizable; that of ammonia forms regular six-sided prisms; that of lime is moderately soluble, and is not affected by the air; that of barytes is soluble in 15 times its weight of water, and crystallizes with difficulty; that of magnesia appears in soluble granular crystals. This acid precipitates from the acetate of lead a white flocculent fungate, which is soluble in distilled vinegar. When insulated, it does not affect solution of nitrate of silver; but the fungates decompose this salt.

ACID (GALLIC). This acid is found in different vegetable substances possessing astringent properties, but most abundantly in the excrescenses termed galls or nut-galls, whence it derives its name. It may be obtained by macerating galls in water, filtering, and suffering the liquor to stand exposed to the air. It will grow mouldy, be covered with a thick glutinous pellicle, abundance of glutinous flocks will fall down, and, in the course of two or three months, the sides of the vessel will appear covered with small yellowish crystals, abundance of which will likewise be found on the under surface of the supernatant pellicle. These crystals may be purified by solution in alcohol, and evaporation to dryness.

M. Deyeux recommends to put the powdered galls into a glass retort, and apply heat slowly and cautiously; when the acid will rise and be condensed in the neck of the retort. This process requires great care, as, if the heat be carried so far as to disengage the oil, the crystals will be dissolved immediately. The crystals thus obtained are pretty large, laminated, and brilliant.

M. Baruel, of the School of Medicine at Paris, finds that he can obtain pure gallic acid by pouring solution of white of egg into the infusion of nut-galls, till this ceases to be disturbed; then to evaporate the clarified liquid to dryness, to heat the residuum with alcohol, to filter the new liquid, and concentrate it to the proper degree for the formation of gallic acid.

The gallic acid placed on a red-hot iron burns with flame, and emits an aromatic smell, not unlike that of benzoic acid. It is soluble in 20 parts of cold water, and in 3 parts at a boiling heat. It is more soluble in alcohol, which takes up an equal weight if heated, and one-fourth of its weight cold.

It has an acido-astringent taste, and reddens tincture of litmus. It does not attract humidity from the air.

From the gallate of lead, Berzelius infers the equivalent of this acid to be 8.00. Its ultimate constituents are, hydrogen 5.00 + carbon 56.64 + oxygen 38.36 = 100.

This acid, in its combinations with the salifiable bases, presents some remarkable phenomena. If we pour its aqueous solution by slow degrees into lime, barytes, or strontites water, there will first be formed a greenish-white precipitate. As the quantity of acid is increased, the precipitate changes to a violet hue, and eventually disappears. The liquid has then acquired a reddish tint. Among the salts, those only of black oxide and red oxide of iron are decomposed by the pure gallic acid. It forms a blue precipitate with the first, and a brown with the second. But when this acid is united with tannin, it decomposes almost all the salts of the permanent metals.

Concentrated sulphuric acid decomposes and carbonizes it; and the nitric acid converts it into malic and oxalic acids.

United with barytes, strontites, lime, and magnesia, it forms salts of a dull yellow colour, which are little soluble, but more so if their base be in excess. With alkalis it forms salts that are not very soluble in general.

Its most distinguishing characteristic is its great affinity for metallic oxides, so as, when combined with tannin, to take them from powerful acids. The more readily the metallic oxides part with their oxygen, the more they are alterable by the gallic acid. To a solution of gold, it imparts a green hue; and a brown precipitate is formed, which readily passes to the metallic state, and covers the solution with a shining golden pellicle. With nitric solution of silver, it produces a similar effect. Mercury it precipitates of an orange-yellow; copper, brown; bismuth, of a lemon colour; lead, white; iron, black. Platina, zinc, tin, cobalt, and manganese, are not precipitated by it.

On dissolving gallic acid in ammonia, and placing the solution in contact with oxygen, M. Dobereiner found that it absorbed sufficient to convert all the hydrogen of the gallic acid into water. In this way the acid is converted into *ulmin*, which is composed of 2 atoms carbon + 1 hydrogen + 2 oxygen. 100 parts of gallic acid absorb 38 of oxygen, within 24 hours. The solution meanwhile becomes brown coloured and opaque.

The gallic acid is of extensive use in the art of dyeing, as it constitutes one of the principal ingredients in all the shades of black, and is employed to fix or improve several other colours. It is well known as an ingredient in ink. See GALLS, DYEING, INK, and SALT.

ACID (HYDRIODIC). This acid resembles the muriatic in being gaseous in its insulated state. If four parts of iodine be mixed with one of phosphorus, in a small glass retort, applying a gentle heat, and adding a few drops of water from time to time, a gas comes over, which must be received in the mercurial bath. Its specific gravity is 4.4; 100 cubic inches, therefore, weigh 134.2 grains. It is elastic and invisible, but has a smell somewhat similar to that of muriatic acid. Mercury after some time decomposes it, seizing its iodine, and leaving its hydrogen, equal to one-half of the original bulk, at liberty. Chlorine, on the other hand, unites to its hydrogen, and precipitates the iodine. From these experiments, it evidently consists of vapour of iodine and hydrogen, which combine in equal volumes, without change of their primitive bulk. Its composition by weight is therefore 8.61 of iodine + 0.0694 hydrogen, which is the relation of their gasiform densities; and if 8.61 be divided by 0.0694, it will give the prime of iodine 124 times greater than hydrogen; and as the prime of oxygen is eight times more than that of hydrogen, on dividing 124 by 8, we have 15.5 for the prime equivalent of iodine; to which, if we add 0.125, the sum 15.625 represents the equivalent of hydriodic acid. The number deduced for iodine, from the relation of iodine to hydrogen in volume, approaches very nearly to 15.621, which was obtained in the other experiments of M. Gay Lussac. Hydriodic acid is partly decomposed at a red heat, and the decomposition is complete if it be mixed with oxygen. Water is formed, and iodine separated.

M. Gay Lussac, in his admirable memoir on iodine and its combinations, published in the Ann. de Chimie, vol. xci. says, that the specific gravity he there gives for hydriodic gas, viz. 4.443, must be a little too great, for traces of moisture were seen in the inside of the bottle. In fact, if we take 15.621 as the prime of iodine to oxygen, whose specific gravity is 1.1111; and multiply one-half of this number by 15.621, as he does, we shall have a product of 8.6696, to which adding 0.0694 for the density of hydrogen, we get the sum 8.7390, one-half of which is obviously the density of the hydriodic gas = 4.3695. When the prime of iodine is taken at 15.5, then the density of the gas comes out 4.3.

We can easily obtain an aqueous hydriodic acid very economically, by passing sulphuretted hydrogen gas through a mixture of water and iodine in a Woolfe's bottle. On heating the liquid obtained, the excess of sulphur flies off, and leaves liquid hydriodic acid. At temperatures below 262°, it parts with its water; and becomes of a density = 1.7. At 262° the acid distils over. When exposed to the air, it is speedily decomposed, and iodine is evolved. Concentrated sulphuric and nitric acids also decompose it. When poured into a saline solution of lead, it throws down a fine orange precipitate. With solution of peroxide of mercury, it gives a red precipitate; and with that of silver, a white precipitate insoluble in ammonia. Hydriodic acid may also be formed, by passing hydrogen over iodine at an elevated temperature.

The compounds of hydriodic acid with the salifiable bases may be easily formed, either by direct combination, or by acting on the basis in water, with iodine. The latter mode is most economical. Upon a determinate quantity of iodine, pour solution of potash or soda, till the liquid ceases to be coloured. Evaporate to dryness, and digest the dry salt in alcohol of the specific gravity 0.810, or 0.820. As the iodate is not soluble in this liquid, while the hydriodate is very soluble, the two salts easily separate from each other. After having washed the iodate two or three times with alcohol, dissolve it in water, and neutralize it with acetic acid. Evaporate to dryness, and digest the dry salt in alcohol, to remove the acetate. After two or three washings, the iodate is pure. As for the alcohol containing the hydriodate, distil it off, and then complete the neutralization of the potash, by means of a little hydriodic acid separately obtained.

Sulphurous and muriatic acids, as well as sulphuretted hydrogen, produce no change on the hydriodates, at the usual temperature of the air.

Chlorine, nitric acid, and concentrated sulphuric, instantly decompose them, and separate the iodine.

With solution of silver, they give a white precipitate insoluble in ammonia; with the pernitrate of mercury, a greenish-yellow precipitate; with corrosive sublimate, a precipitate of a fine orange-red, very soluble in an excess of hydriodate; and with nitrate of lead, a precipitate of an orange-yellow colour. They dissolve *iodine*, and acquire a deep reddish-brown colour.

Hydriodate of potash, or, in the dry state, iodide of potassium, yields crystals like sea-salt, which melt and sublime at a red heat. This salt is not changed by being heated in contact with air. 100 parts of water at 64°, dissolve 143 of it. It consists of 15.5 iodine, and 5 potassium.

Hydriodate of soda, called in the dry state *iodide of sodium*, may be obtained in pretty large flat rhomboidal prisms. These prisms unite together with larger ones, terminated in echellon, and striated longways, like those of sulphate of soda. This is a true hydriodate, for it contains much water of crystallization. It consists, when dry, of 15.5 iodine + 3 sodium.

Hydriodate of barytes crystallizes in fine prisms, similar to muriate of strontites. In its dry state it consists of 15.5 iodine + 8.75 barium.

The *hydriodates of lime* and *strontites* are very soluble; and the first exceedingly deliquescent.

Hydriodate of ammonia results from the combination of equal volumes of ammoniacal and hydriodic gases; though it is usually prepared by saturating the liquid acid with ammonia. It is nearly as volatile as sal ammoniac; but it is more soluble and more deliquescent. It crystallizes in cubes. From this compound we may infer the prime of hydriodic acid, from the specific gravity of the hydriodic gas; or having the prime, we may determine the sp. gr. If we call 15.625 its equivalent, then we have this proportion:—As a prime of ammonia, to a prime of hydriodic acid, so is the density of ammoniacal, to that of hydriodic gas.

$$2.125 : 15.625 :: 0.59 : 4.3.$$

This would make 100 cubic inches weigh exactly 132 grains.

Hydriodate of magnesia is formed by uniting its constituents together; it is deliquescent, and crystallizes with difficulty.—It is decomposed by a strong heat.

Hydriodate of zinc is easily obtained, by putting iodine into water with an excess of zinc, and favouring their action by heat. When dried it becomes an iodide.

All the hydriodates have the property of dissolving abundance of iodine; and thence they acquire a deep reddish-brown colour. They part with it on boiling, or when exposed to the air after being dried. See SALT.

ACID (HYDROBROMIC). Put bromine and phosphorus in contact, and moisten them with a few drops of water. A gaseous matter is evolved, which may be collected over mercury, and which is hydrobromic acid. It is colourless. Taste acid. It diffuses in the air white vapours, denser than those of muriatic acid in the same circumstances, and which excite coughing. This gas is not decomposed by traversing an ignited tube, either alone, or mixed with oxygen. It is instantly decomposed by chlorine, which, seizing the hydrogen, produces immediately abundant ruddy vapours, and a deposit of bromine in small drops. Tin and potassium also decompose hydrobromic acid, and one half of its volume of hydrogen remains. This gaseous acid combines readily with water. The solution is colourless when rightly prepared; but excess of bromine gives it a deep ruddy hue. Iron, zinc, and tin dissolve in the liquid acid, with disengagement of hydrogen. Bromine has for hydrogen a weaker affinity than chlorine has, but a stronger than iodine.

As the prime equivalent of bromine is inferred from the bromide of potassium to be about 9.5, that of hydrobromic acid should be 9.625, or 77 times the weight of the prime of hydrogen. *Balard, Annales de Chim. et Phys.* xxxii. 347.

ACID (IODIC). When barytes water is made to act on iodine, a soluble hydriodate, and an insoluble iodate of barytes, are formed. On the latter, well washed, pour sulphuric acid equivalent to the barytes present, diluted with twice its weight of water, and heat the mixture. The iodic acid quickly abandons a portion of its base, and combines with the water; but though even less than the equivalent proportion of sulphuric acid has been used, a little of it will be found mixed with the liquid acid. If we endeavour to separate this portion, by adding barytes water, the two acids precipitate together.

The above economical process is that of M. Gay Lussac; but Sir H. Davy, who is the discoverer of this acid in a solid state, invented one which yields a purer acid. Into a long glass tube, bent like the letter L inverted (┐), shut at one end, put 100 grains of chlorate of potash, and pour over it 400 grains of muriatic acid, specific gravity 1.105. Put 40 grains of iodine into a thin long-necked receiver. Into the open end of the bent tube put some muriate of lime, and then connect it with the receiver. Apply a gentle heat to the sealed end of the former. Protoxide of chlorine is evolved, which, as it comes in contact with the iodine, produces combustion, and two new compounds, a compound of iodine and oxygen, and one of iodine and chlorine. The latter is easily separable by heat, while the former remains in a state of purity.

The iodic acid of Sir H. Davy is a white semitransparent solid. It has a strong acido-astringent taste, but no smell. Its density is considerably greater than that of sulphuric acid, in which it rapidly sinks. It melts, and is decomposed into iodine and oxygen, at a temperature of about 620°. A grain of iodic acid gives out 176.1 grain measures of oxygen gas. It would appear from this, that iodic acid consists of 15.5 iodine, to 5 oxygen. This agrees with the determination of M. Gay Lussac, obtained from much greater quantities; and must therefore excite admiration at the precision of result derived by Sir H. from the very minute proportions which he used. 176.1 grain measures are equal to 0.7 of a cubic inch; which, calling 100 cubic inches 33.88, will weigh 0.237 of a grain, leaving 0.763 for iodine. And 0.763 : 0.237 :: 15.5 : 5.0.

Iodic acid deliquesces in the air, and is, of course, very soluble in water. It first reddens and then destroys the blues of vegetable infusions. It blanches other vegetable colours. By concentration of the liquid acid of Gay Lussac, it acquires the consistence of syrup. When the temperature of inspissated iodic acid is raised to about 392°, it is resolved into iodine and oxygen. Here we see the influence of water is exactly the reverse of what M. Gay Lussac assigns to it; for, instead of giving fixity like a base to the acid, it favours its decomposition. The dry acid may be raised to upwards of 600° without being decomposed. Sulphurous acid, and sulphuretted hydrogen, immediately separate iodine from it. Sulphuric and nitric acids have no action on it. With solution of silver, it gives a white precipitate, very soluble in ammonia. It combines with all the bases, and produces all the iodates which we can obtain by making the alkaline bases act upon iodine in water. It likewise forms with ammonia a salt, which fulminates when heated. Between the acid prepared by M. Gay Lussac, and that of Sir H. Davy, there is one important difference. The latter being dissolved, may, by evaporation of the water, pass not only to the inspissated syrupy state, but can be made to assume a pasty consistence; and finally, by a stronger heat, yields the solid substance unaltered. When a mixture of it, with charcoal, sulphur, resin, sugar, or the combustible metals, in a finely divided state, is heated, detonations are produced; and its solution rapidly corrodes all the metals to which Sir H. Davy exposed it, both gold and platinum, but much more intensely the first of these metals.

It appears to form combinations with all the fluid or solid acids which it does not decompose. When sulphuric acid is dropped into a concentrated solution of it in hot water, a solid substance is precipitated, which consists of the acid and the compound: for, on evaporating the solution by a gentle heat, nothing rises but water. On increasing the heat in an experiment of this kind, the solid substance formed fused; and on cooling the mixture, rhomboidal crystals formed of a pale yellow colour, which were very fusible, and which did not change at the heat at which the compound of oxygen and iodine decomposes, but sublimed unaltered. When urged by a much stronger heat, it partially sublimed, and partially decomposed, affording oxygen, iodine, and sulphuric acid.

With hydro-phosphoric, the compound presents phenomena precisely similar, and they form together a solid, yellow, crystalline combination.

With hydro-nitric acid, it yields white crystals in rhomboidal plates, which, at a lower heat than the preceding acid compounds, are resolved into hydro-nitric acid, oxygen, and iodine. By liquid muriatic acid, the substance is immediately decomposed, and the compound of chlorine and iodine is formed. All these acid compounds redden vegetable blues, taste sour, and dissolve gold and platinum. From these curious researches Sir H. Davy infers, that M. Gay Lussac's iodic acid is a sulpho-iodic acid, and probably a definite compound. However minute the quantity of sulphuric acid made to act on the iodide of barium may be, a part of it is always employed to form the compound acid; and the residual fluid contains both the compound acid and a certain quantity of the original salt.

In treating of hydriodic acid, we have already described the method of forming the iodates, a class of salts distinguished chiefly by their property of deflagrating when heated with combustibles. See SALT.

ACID (IODOUS). Equal parts of chlorate of potash and iodine are to be triturated together in a glass or porcelain mortar, until they form a fine pulverulent yellow mass, in which the metallic aspect of the iodine has entirely disappeared. This mixture is to be put into a retort, the neck being preserved clean, and a receiver is to be attached with a tube passing to the pneumatic trough. Heat is then to be applied; and for this purpose a spirit lamp will be sufficient; at first a few violet vapours rise, but as soon as the chlorate begins to lose oxygen, dense yellow fumes will appear, which will be condensed in the neck of the retort into a yellow liquid, and run in drops into the receiver; oxygen gas will at the same time come over. When the vapour ceases to rise, the process is finished, and the iodous acid obtained will have the following properties.

Its colour is yellow; taste acid and astringent, leaving a burning sensation on the tongue. It is of an oily consistency, and flows with difficulty. It is denser than water. Its odour somewhat resembles that of euchlorine. It reddens vegetable blues, but does not destroy them. At 112° F. it volatilizes rapidly in dense fumes. It dissolves iodine, and assumes a deep colour. *Sementini, Bib. Univ.* xxv. 119.

ACID (CHLORIODIC). The discovery of this interesting compound constitutes another of Sir H. Davy's contributions to the advancement of science. In a communication from Florence to the Royal Society, in March 1814, he gives a curious detail of its preparation and properties. He formed it, by admitting chlorine in excess to known quantities of iodine, in vessels exhausted of air, and repeatedly heating the sublimate. Operating in this way, he found that iodine absorbs less than one-third of its weight of chlorine.

Chloriodic acid is a very volatile substance, and in consequence of its action upon mercury, he was not able to determine the elastic force of its vapour. In the most considerable experiment which he made to determine proportions, 20 grains caused the disappearance of 9.6 cubical inches of chlorine. These weigh 7.296 grains. And 20 : 7.296 :: 15.5 : 5.6, a number not very far from 4.5, the prime equivalent of chlorine; and in the delicate circumstances of the experiment, an approximation not to be disparaged. Indeed, the first result in close vessels, giving less than one-third of the weight of chlorine absorbed, comes sufficiently near 4.5, which is just a little less than one-third of 15.5, the prime equivalent of iodine.

The chloriodic acid formed by the sublimation of iodine in a great excess of chlorine is of a bright yellow colour; when fused it becomes of a deep orange, and when rendered elastic, it forms a deep orange-coloured gas. It is capable of combining with much iodine when they are heated together; its colour becomes, in consequence, deeper, and the chloriodic acid and the iodine rise together in the elastic state. The solution of the chloriodic acid in water likewise dissolves large quantities of iodine, so that it is possible to obtain a fluid containing very different proportions of iodine and chlorine.

When two bodies so similar in their characters, and in the compounds they form, as iodine and chlorine, act upon substances at the same time, it is difficult, Sir H. observes, to form a judgment of the different parts that they play in the new chemical arrangement produced. It appears most probable, that the acid property of the chloriodic compound depends upon the combination of the two bodies; and its action upon solutions of the alkalis and the earths may be easily explained, when it is considered that chlorine has a greater tendency than iodine to form double compounds with the metals, and that iodine has a greater tendency than chlorine to form triple compounds with oxygen and the metals.

A triple compound of this kind with sodium may exist in sea water, and would be separated with the first crystals that are formed by its evaporation. Hence, it may exist in common salt. Sir H. Davy ascertained, by feeding birds with bread soaked with water, holding some of it in solution, that it is not poisonous like iodine itself.

ACID (HYDROCYANIC). See ACID (PRUSSIC).

ACID (HYDROSELENIC). The best process which we can employ for procuring this acid, according to M. Berzelius, consists in treating the seleniuret of iron with the liquid muriatic acid: (*Ann. de Chim. et de Phys.* ix. 243.) The acid gas evolved must be collected over mercury. As in this case a little of another gas, condensible neither by water nor alkaline solutions, appears, the best substance for obtaining absolutely pure hydroselenic acid would be seleniuret of potassium.

Seleniuretted hydrogen gas is colourless. It reddens litmus. Its density has not been determined by experiment. Its smell resembles, at first, that of sulphuretted hydrogen gas; but the sensation soon changes, and another succeeds, which is at once pungent, astringent, and painful. The eyes become almost instantly red and inflamed, and the sense of smelling entirely disappears. A bubble of the size of a little pea is sufficient to produce these effects. Of all the bodies derived from the inorganic kingdom, seleniuretted hydrogen is that which exercises the strongest action on the animal economy. Water dissolves this gas; but in what proportions is not known. This solution disturbs almost all the metallic solutions, producing black or brown precipitates, which assume, on rubbing with polished hæmatites, a metallic lustre. Zinc, manganese, and cerium, form exceptions. They yield flesh-coloured precipitates, which appear to be hydro-seleniurets of the oxides, whilst the others, for the most part, are merely metallic seleniurets.

ACID (HYDROXANTHIC). If a certain quantity of sulphuret of carbon be poured into an alcoholic solution of one of the alkalis, a neutral liquid is obtained, in consequence of the formation of a new acid, which neutralizes the alkali. If potash has been used, the salt may be obtained either by refrigeration, evaporation, or precipitation by sulphuric ether. It contains no carbonic acid, or sulphuretted hydrogen, but an acid which is in the same relation to sulphuret of carbon, that hydrocyanic acid is to cyanogen. Its compounds have been called hydroxanthates. The acid may be obtained by pouring a mixture of four parts of sulphuric acid and three of water on the salt of potash, and in a few seconds adding abundance of water. The acid collects at the bottom of the water as a transparent slightly coloured oil; it must be quickly washed with water until free from sulphuric acid. This acid reddens litmus paper powerfully. Its odour differs from that of sulphuret of carbon. Its taste is acid and astringent. It burns readily, giving out sulphurous fumes. *Dr. Zeise of Copenhagen, Journal of Science*, xv. 304.

ACID (HYPONITROUS). See ACID (NITRIC).

ACID (HYPOPHOSPHORIC). See ACID (PHOSPHORIC).

ACID (HYPOPHOSPHOROUS). See ACID (PHOSPHOROUS).

ACID (HYPOSULPHURIC). See ACID (SULPHURIC).

ACID (HYPOSULPHUROUS). See ACID (SULPHUROUS).

ACID (IGASURIC). MM. Pelletier and Caventou, in their elegant researches on the *faba Sancti Ignatii, et nux vomica*, having observed that these substances contained a new vegetable base (strychnine) in combination with an acid, sought to separate the latter, in order to determine its nature. It appeared to them to be new, and they called it igasuric acid, from the Malay name by which the natives designate in the Indies the *faba Sancti Ignatii*. This bean, according to these chemists, is composed of igasurate of strychnine, a little wax, a concrete oil, a yellow colouring matter, gum, starch, bassorine, and vegetable fibre.

To extract the acid, the rasped bean must be heated in ether, in a digester, with a valve of safety. Thus the concrete oil, and a little igasurate of strychnine, are dissolved out. When the powder is no longer acted on by the ether, they subject it, at several times, to the action of boiling alcohol, which carries off the oil which had escaped the ether, as also wax, which is deposited on cooling, some igasurate of strychnine, and colouring matter. All the alcoholic decoctions are united, filtered, and evaporated. The brownish-yellow residuum is diffused in water; magnesia is now added, and the whole is boiled together for some minutes. By this means, the igasurate is decomposed, and from this decomposition there results free strychnine, and a sub-igasurate of magnesia, very little soluble in water. Washing with cold water removes almost completely the colouring matter, and boiling alcohol then separates the strychnine, which falls down as the liquid cools. Finally, to procure igasuric acid from the sub-igasurate of magnesia, which remains united to a small quantity of colouring matter, we must dissolve the magnesian salt in a great body of boiling distilled water; concentrate the liquor, and add to it acetate of lead, which immediately throws down the acid in the state of an igasurate of lead. This compound is then decomposed, by transmitting a current of sulphuretted hydrogen through it, diffused in 8 or 10 times its weight of boiling water.

This acid, evaporated to the consistence of syrup, and left to itself, concretes in hard and granular crystals. It is very soluble in water, and in alcohol. Its taste is acid and very styptic. It combines with the alkaline and earthy bases, forming salts soluble in water and alcohol. Its combination with barytes is very soluble, and crystallizes with difficulty, and mushroom-like. Its combination with ammonia, when perfectly neutral, does not form a precipitate with the salts of silver, mercury, and iron; but it comports itself with the salts of copper in a peculiar manner, and which seems to characterize the acid of *strychnos* (for the same acid is found in *nux vomica*, and in snake-wood, *bois de couleuvre*): this effect consists in the decomposition of the salts of copper, by its ammoniacal compound. These salts pass immediately to a green colour, and gradually deposit a greenish-white salt, of very sparing solubility in water. The acid of *strychnos* seems thus to resemble meconic acid; but it differs essentially from it, by its action with salts of iron, which immediately assume a very deep red colour with the meconic acid; an effect not produced by the acid of *strychnos*. The authors, after all, do not positively affirm this acid to be new and peculiar.—*Ann. de Chim. et de Phys.* x. 142.

ACID (IODO-SULPHURIC). When we pour sulphuric acid, drop by drop, into a concentrated and hot aqueous solution of iodic acid, there immediately results a precipitate of iodo-sulphuric acid, possessed of peculiar properties. Exposed gradually to the action of a gentle heat, the iodo-sulphuric acid melts, and crystallizes on cooling into rhomboids of a pale yellow colour. When strongly heated, it sublimes, and is partially decomposed; the latter portion being converted into oxygen, iodine, and sulphuric acid.

Phosphoric and nitric acids exhibit similar phenomena. These compound acids act with great energy on the metals. They dissolve gold and platinum.

ACID (HYDROTHIONIC). Some of the German chemists distinguished sulphuretted hydrogen by this name, on account of its properties resembling those of an acid.

ACID (IODIC). See p. 38.

ACID (IODOUS). See p. 39.

ACID (KINIC). A peculiar acid extracted by M. Vauquelin from cinchona. Let a watery extract from hot infusions of the bark in powder be made. Alcohol removes the resinous part of this extract, and leaves a viscid residue, of a brown colour, which has hardly any bitter taste, and which consists of kinate of lime and a mucilaginous matter. This residue is dissolved in water, the liquor is filtered and left to spontaneous evaporation in a warm place. It becomes thick like syrup, and then deposits by degrees crystalline plates, sometimes hexaëdral, sometimes rhomboidal, sometimes square, and always coloured slightly of a reddish-brown. These plates of kinate of lime must be purified by a second crystallization. They are then dissolved in 10 or 12 times their weight of water, and very dilute aqueous oxalic acid is poured into the solution, till no more precipitate is formed. By filtration, the oxalate of lime is separated, and the kinic acid being concentrated by spontaneous evaporation, yields regular crystals. It is decomposed by heat. While it forms a soluble salt with lime, it does not precipitate lead or silver from their solutions. These are characters sufficiently distinctive. The kinates are scarcely known; that of lime constitutes 7 per cent. of *cinchona*.

ACID (KRAMERIC). A peculiar substance which M. Peschier, of Geneva, thought he had found in the root of the *Krameria triandria*.

ACID (LACCIC) of Dr. John.

This chemist made a watery extract of powdered stick lac, and evaporated it to dryness. He digested alcohol on this extract, and evaporated the alcoholic extract to dryness. He then digested this mass in ether, and evaporated the ethereal solution; when he obtained a syrupy mass of a light yellow colour, which was again dissolved in alcohol. On adding water to this solution a little resin fell. A peculiar acid united to potash and lime remains in the solution, which is obtained free, by forming with acetate of lead an insoluble laccate, and decomposing this with the equivalent quantity of sulphuric acid. Laccic acid crystallizes; it has a wine-yellow colour, a sour taste, and is soluble, as we have seen, in water, alcohol, and ether. It precipitates lead and mercury white; but it does not affect lime, barytes, or silver, in their solutions. It throws down the salts of iron white. With lime, soda, and potash, it forms deliquescent salts, soluble in alcohol.

ACID (LACTIC). The extract which is obtained when dried whey is digested with alcohol contains uncombined lactic acid, lactate of potash, muriate of potash, and a proper animal matter. As the elimination of the acid affords an instructive example of chemical research, we shall present it at some detail from the 2d volume of Berzelius's Animal Chemistry.

He mixed the above alcoholic solution with another portion of alcohol, to which $\frac{1}{10}$ of concentrated sulphuric acid had been added, and continued to add fresh portions of this mixture as long as any saline precipitate was formed, and until the fluid had acquired a decidedly acid taste. Some sulphate of potash was precipitated, and there remained in the alcohol, muriatic acid, lactic acid, sulphuric acid, and a minute portion of phosphoric acid, detached from some bone earth which had been held in solution. The acid liquor was filtered, and afterwards digested with carbonate of lead, which with the lactic acid affords a salt soluble in alcohol. As soon as the mixture had acquired a sweetish taste, the three mineral acids had fallen down in combination with the lead, and the lactic acid remained behind, imperfectly saturated by a portion of it, from which it was detached by means of sulphuretted hydrogen, and then evaporated to the consistence of a thick varnish, of a dark brown colour, and sharp acid taste, but altogether without smell.

In order to free it from the animal matter which might remain combined with it, he boiled it with a mixture of a large quantity of fresh lime and water, so that the animal substances were precipitated and destroyed by the lime. The lime became yellow-brown, and the solution almost colourless, while the mass emitted a smell of soap lees, which disappeared as the boiling was continued. The fluid thus obtained was filtered, and evaporated, until a great part of the superfluous lime held in solution was precipitated. A small portion of it was then decomposed by oxalic acid, and carbonate of silver was dissolved in the uncombined lactic acid, until it was fully saturated. With the assistance of the lactate of silver thus obtained, a further quantity of muriatic acid was separated from the lactate of lime, which was then decomposed by pure oxalic acid, free from nitric acid, taking care to leave it in such a state that neither the oxalic acid nor lime water afforded a precipitate. It was then evaporated to dryness, and dissolved again in alcohol, a small portion of oxalate of lime, before retained in union with the acid, now remaining undissolved. The alcohol was evaporated until the mass was no longer fluid while warm; it became a brown clear transparent acid, which was the lactic acid, free from all substances that we have hitherto had reason to think likely to contaminate it.

The lactic acid, thus purified, has a brown-yellow colour, and a sharp sour taste, which is much weakened by diluting it with water. It is without smell in the cold, but emits, when heated, a sharp sour smell, not unlike that of sublimed oxalic acid. It cannot be made to crystallize, and does not exhibit the slightest appearance of a saline substance, but dries into a thick and smooth varnish, which slowly attracts moisture from the air. It is very easily soluble in alcohol. Heated in a gold spoon over the flame of a candle, it first boils, and then its pungent acid smell becomes very manifest, but extremely distinct from that of the acetic acid; afterwards it is charred, and has an empyreumatic, but by no means an animal smell. A porous charcoal is left behind, which does not readily burn to ashes. When distilled, it gives an empyreumatic oil, water, empyreumatic vinegar, carbonic acid, and inflammable gases. With alkalis, earths, and metallic oxides, it affords peculiar salts: and these are distinguished by being soluble in alcohol, and in general by not having the least disposition to crystallize, but drying into a mass like gum, which slowly becomes moist in the air.

Lactate of potash is obtained, when the lactate of lime, purified as has been mentioned, is mixed with a warm solution of carbonate of potash. It forms, in drying, a gummy, light yellow-brown, transparent mass, which cannot easily be made hard. If it is mixed with concentrated sulphuric acid, no smell of acetic acid is perceived; but if the mixture is heated, it acquires a disagreeable pungent smell, which is observable in all animal substances mixed with the sulphuric acid. The extract which is obtained directly from milk, contains this salt; but this affords, when mixed with sulphuric acid, a sharp acid smell, not unlike that of the acetic acid. This, however, depends not on acetic but on muriatic acid, which in its concentrated state introduces this modification into the smell of almost all organic bodies. The pure lactate of potash is easily soluble in alcohol; that which contains an excess of potash, or is still contaminated with the animal matter soluble in alcohol, which is destroyed by the treatment with lime, is slowly soluble, and requires about 14 parts of warm alcohol for its solution. It is dissolved in boiling alcohol more abundantly than in cold, and separates from it, while it is cooling, in the form of hard drops.

The *lactate of soda* resembles that of potash, and can only be distinguished from it by analysis.

Lactate of ammonia. If concentrated lactic acid is saturated with caustic ammonia in excess, the mixture acquires a strong volatile smell, not unlike that of the acetate or formiate of ammonia, which, however, soon ceases. The salt which is left has sometimes a slight tendency to shoot into crystals. It affords a gummy mass, which in the air acquires an excess of acidity. When heated, a great part of the alkali is expelled, and a very acid salt remains, which deliquesces in the air.

The *lactate of barytes* may be obtained in the same way as that of lime; but it then contains an excess of the base. When evaporated, it affords a gummy mass, soluble in alcohol. A portion remains undissolved, which is a subsalt, is doughy, and has a browner colour. That which is dissolved in the alcohol affords by evaporation an almost colourless gummy mass, which hardens into a stiff but not a brittle varnish. It does not show the least tendency to crystallize. The salt, which is less soluble in alcohol, may be further purified from the animal matter adhering to it, by adding to it more barytes, and then becomes more soluble.

The *lactate of lime* is obtained in the manner above described. It affords a gummy mass, which is also divided by alcohol into two portions. The larger portion is soluble, and gives a shining varnish, inclining to a light yellow colour, which, when slowly dried, cracks all over, and becomes opaque. This is pure lactate of lime. That which is insoluble in alcohol is a powder, with excess of the base; received on a filter, it becomes smooth in the air like gum, or like malate of lime. By boiling with more lime, and by the precipitation of the superfluous base upon exposure to the air, it becomes pure and soluble in alcohol.

Lactate of magnesia, evaporated to the consistence of a thin syrup, and left in a warm place, shoots into small granular crystals. When hastily evaporated to dryness, it affords a gummy mass. With regard to alcohol, its properties resemble those of the two preceding salts.

Ammoniaco-magnesian lactate is obtained by mixing the preceding salt with caustic ammonia, as long as any precipitation continues. By spontaneous evaporation this salt shoots into needle-shaped prisms, which are little coloured, and do not change in the air. Berzelius has once seen these crystals form in the alcoholic extract of milk boiled to dryness; but this is by no means a common occurrence.

The *lactate of silver* is procured by dissolving the carbonate in the lactic acid. The solution is of a light yellow, somewhat inclining to green, and has an unpleasant taste of verdigris. When evaporated in a flat vessel, it dries into a very transparent greenish-yellow varnish, which has externally an unusual splendour like that of a looking-glass. If the evaporation is conducted in a deeper vessel, and with a stronger heat, a part of the salt is decomposed, and remains brown from the reduction of the silver. If this salt is dissolved in water, no inconsiderable portion of the silver is reduced and deposited, even when the salt has been transparent; and the concentrated solution has a fine greenish-yellow colour, which by dilution becomes yellow. If we dissolve the oxide of silver in an impure acid, the salt becomes brown, and more silver is revived during the evaporation.

The *lactate of the protoxide of mercury* is obtained when the lactic acid is saturated with black oxidated mercury. It has a light yellow colour, which disappears by means of repeated solution and evaporation. The salt exhibits acid properties, deliquesces in the air, and is partially dissolved in alcohol, but is at the same time decomposed, and deposits carbonate of mercury, while the mixture acquires a slight smell of ether. The lactic acid dissolves also the red oxide of mercury, and gives with it a red gummy deliquescent salt. If it is left exposed to a warm and moist atmosphere, it deposits, after the expiration of some weeks, a light semicrystalline powder, which he has not examined, but which probably must be acetate of mercury.

The *lactate of lead* may be obtained in several different degrees of saturation. If the lactic acid is digested with the carbonate of lead, it becomes browner than before, but cannot be fully saturated with the oxide; and we obtain an acid salt, which does not crystallize, but dries into a syrup-like brown mass, with a sweet austere taste. When a solution of lactic acid in alcohol is digested with finely powdered litharge until the solution becomes sweet, and is then slowly evaporated to the consistence of honey, the neutral lactate of lead crystallizes in small greyish grains, which may be rinsed with alcohol, to wash off the viscid mass that adheres to them, and will then appear as a grey granular salt, which when dry is light and silvery.

This silver-grained salt does not change in the air; treated with sulphuretted hydrogen it affords pure lactic acid. If the lactic acid is digested with a greater portion of levigated litharge than is required for its saturation, the fluid acquires first a browner colour, and as the digestion is continued the colour becomes more and more pale, and the oxide swells into a bulky powder, of a colour somewhat lighter than before. If the fluid is evaporated, and water is then poured on the dry mass, a very small portion of it only is dissolved; the solution is not coloured, and when it is exposed to the air, a pellicle of carbonate of lead is separated from it. If the dried salt of lead be boiled with water, and the solution be filtered while hot, a great part of that which had been dissolved will be precipitated while it cools, in the form of a white, or light yellow powder, which is a sub-lactate of lead. This salt is of a light flame colour; when dried, it remains mealy, and soft to the touch, and it is decomposed by the weakest acids, while the acid salt is dissolved in water, exhibiting a sweet taste and a brown colour. When moistened with water, it undergoes this change from the operation of the carbonic acid diffused in the air. If this salt is warmed and then set on fire at one point, it burns like tinder, and leaves the lead in great measure reduced. A hundred parts of this salt, dissolved in nitric acid, and precipitated with carbonate of potash, gave exactly 100 parts of carbonate of lead; consequently its component parts, determined from those of the carbonate, must be 83 of the oxide of lead, and 17 of the lactic acid. At the same time we cannot wholly depend on this proportion, and it certainly makes the quantity of lead somewhat too great. The relation of the lactic acid to lead affords one of the best methods of recognizing it, and Berzelius always principally employed it in extracting this acid from animal fluids; it gives the clearest distinction between the lactic acid and the acetic.

The *lactate of iron* is of a red-brown colour, does not crystallize, and is not soluble in alcohol. The *lactate of zinc* crystallizes. Both these metals are dissolved by the lactic acid, with an extrication of hydrogen gas. The *lactate of copper*, according to its different degrees of saturation, varies from blue to green and dark blue. It does not crystallize.

It is only necessary to compare the descriptions of these salts with what we know of the salts which are formed with the same bases by other acids, for example, the acetic, the malic, and others, in order to be completely convinced that the lactic acid must be a peculiar acid, perfectly distinct from all others. Its prime equivalent may be called 5.8.

The *nanceic acid* of Braconnot resembles the lactic in many respects.

ACID (LITHIC). Lithate of potash is obtained by digesting human urinary calculi in caustic lixivium; and Fourcroy recommends the precipitation of the lithic acid from this solution by acetic acid, as a good process for obtaining the acid pure, in small, white, shining, and almost pulverulent needles.

It has the form of white shining plates, which are denser than water. Has no taste nor smell. It dissolves in about 1400 parts of boiling water. It reddens the infusion of litmus. When dissolved in nitric acid, and evaporated to dryness, it leaves a pink sediment. The dry acid is not acted on nor dissolved by the alkaline carbonates, or sub-carbonates. It decomposes soap when assisted by heat; as it does also the alkaline sulphurets and hydrosulphurets. No acid acts on it, except those that occasion its decomposition. It dissolves in hot solutions of potash and soda, and likewise in ammonia, but less readily. The lithates may be formed, either by mutually saturating the two constituents, or we may dissolve the acid in an excess of base, and we may then precipitate by carbonate of ammonia. The lithates are all tasteless, and resemble in appearance lithic acid itself. They are not altered by exposure to the atmosphere. They are very sparingly soluble in water. They are decomposed by a red heat, which destroys the acid. The lithic acid is precipitated from these salts by all the acids, except the prussic and carbonic. They are decomposed by the nitrates, muriates, and acetates of barytes, strontites, lime, magnesia, and alumina. They are precipitated by all the metallic solutions, except that of gold. When lithic acid is exposed to heat, the products are carburetted hydrogen, and carbonic acid, prussic acid, carbonate of ammonia, a sublimate, consisting of ammonia combined with a peculiar acid, which has the following properties:—

Its colour is yellow, and it has a cooling bitter taste. It dissolves readily in water, and in alkaline solutions, from which it is not precipitated by acids. It dissolves also sparingly in alcohol. It is volatile, and when sublimed a second time, becomes much whiter. The watery solution reddens vegetable blues, but a very small quantity of ammonia destroys this property. It does not cause effervescence with alkaline carbonates. By evaporation it yields permanent crystals, but ill defined, from adhering animal matter. These redden vegetable blues. Potash, when added to these crystals, disengages ammonia. When dissolved in nitric acid, they do not leave a red stain, as happens with uric acid; nor does their solution in water decompose the earthy salts, as happens with alkaline lithates (or urates). Neither has it any action on the salts of copper, iron, gold, platinum, tin, or mercury. With nitrates of silver, and mercury, and acetate of lead, it forms a white precipitate, soluble in an excess of nitric acid. Muriatic acid occasions no precipitate in the solution of these crystals in water. These properties show, that the acid of the sublimate is different from the uric, and from every other known acid. Dr. Austin found, that by repeated distillations lithic acid was resolved into ammonia, nitrogen, and prussic acid. See Acid (Pyrolithic).

When lithic acid is projected into a flask with chlorine, there is formed, in a little time, muriate of ammonia, oxalate of ammonia, carbonic acid, muriatic acid, and malic acid; the same results are obtained by passing chlorine through water, holding this acid in suspension.

M. Gay Lussac mixed lithic acid with 20 times its weight of oxide of copper, put the mixture into a glass tube, and covered it with a quantity of copper filings. The copper filings being first heated to a dull red, heat was applied to the mixture. The gas which came over, was composed of 0.69 carbonic acid, and 0.31 nitrogen. He conceives, that the bulk of the carbonic acid would have been exactly double that of the nitrogen, had it not been for the formation of a little carbonate of ammonia. Hence, uric acid contains two prime equivalents of carbon, and one of nitrogen. This is the same proportion as exists in cyanogen. Probably, a prime equivalent of oxygen is present. Dr. Prout, in the eighth vol. of the Med. Chir. Trans. describes the result of an analysis of lithic acid, effected also by ignited oxide of copper, but so conducted as to determine the product of oxygen and hydrogen. Four grains of lithic acid yielded, water 1.06, carbonic acid 11.0 c. inches, nitrogen 5.5 do. Hence, it consisted of

Hydrogen	2.857	or 1 prime	= 0.125
Carbon	34.286	2	= 1.500
Oxygen	22.857	1	= 1.000
Nitrogen	40.00	1	= 1.750
	100.000		4.375

Mr. Berard has published an analysis of lithic acid since Dr. Prout, in which he also employed oxide of copper.

The following are the results:

Carbon	33.61	which approach to	1 Carbon
Oxygen	18.89		1 Oxygen
Hydrogen	8.34		4 Hydrogen
Nitrogen	39.16		1 Nitrogen
	100.00		

Here we find the nitrogen and carbon nearly in the same quantity as by Dr. Prout; but there is much more hydrogen and less oxygen. By urate of barytes, we have the prime equivalent of uric acid equal to 15.67; and by urate of potash it appears to be 14.0. It is needless to try to accommodate an arrangement of prime equivalents to these discrepancies. The lowest number would require, on the Daltonian plan, an association of more than twenty atoms, the grouping of which is rather a sport of fancy than an exercise of reason. For what benefit could accrue to chemical science by stating, that if we consider the atom of lithic acid to be 16.75, then it would probably consist of

7 atoms	Carbon	= 5.25	31.4
3	Oxygen	= 3.00	17.90
12	Hydrogen	= 1.500	8.90
4	Nitrogen	= 7.00	41.80
26		16.75	100.0

ACID (MALIC). The acid of apples; the same with that which is extracted from the fruit of the mountain ash. See Acid (Sorbic).

ACID (MARGARIC). When we immerse soap made of pork-grease and potash, in a large quantity of water, one part is dissolved, while another part is precipitated in the form of several brilliant pellets. These are separated, dried, washed in a large quantity of water, and then dried on a filter. They are now dissolved in boiling alcohol, sp. gr. 0.820, from which, as it cools, the pearly substance falls down pure. On acting on this with dilute muriatic acid, a substance of a peculiar kind, which M. Chevreul, the disevreul, calls margarine, or margaric acid, is separated. It must be well washed with water, dissolved in boiling alcohol, from which it is recovered in the same crystalline pearly form, when the solution cools.

Margaric acid is pearly white, and tasteless. Its smell is feeble, and a little similar to that of melted wax. Its specific gravity is inferior to water. It melts at 134° F. into a very limpid, colourless liquid, which crystallizes, on cooling, into brilliant needles of the finest white. It is insoluble in water, but very soluble in alcohol, sp. gr. 0.800. Cold margaric acid has no action on the colour of litmus; but when heated so as to soften without melting, the blue was reddened. It combines with the salifiable bases, and forms neutral compounds. 100 parts of it unite to a quantity of base containing three parts of oxygen, supposing that 100 of potash contain 17 of oxygen. Two orders of margarates are formed, the margarates and the supermargarates, the former being converted into the latter, by pouring a large quantity of water on them. Other fats besides that of the hog yield this substance.

	Acid.	*Base.*
Margarate of potash consists of	100	17.77
Supermargarate - -	100	8.88
Margarate of soda - - -	100	12.72
Barytes - - -	100	28.93
Strontites - - - -	100	20.23
Lime - - - -	100	11.06
		Potash.
Supermargarate of Human fat	100	8.85
Sheep fat	100	8.68
Ox fat	100	8.78
Jaguar fat	100	8.60
Goose fat	100	8.77

If we compare the above numbers, we shall find 35 to be the prime equivalent of margaric acid.

That of man is obtained under three different forms. 1*st*, In very fine long needles, disposed in flat stars. 2*d*, In very fine and very short needles, forming waved figures, like those of the margaric acid of carcasses. 3*d*, In very large brilliant crystals disposed in stars, similar to the margaric acid of the hog. The margaric acids of man and the hog resemble each other; as do those of the ox and the sheep; and of the goose and the jaguar. The compounds with the bases are real soaps. The solution in alcohol affords the transparent soap of this country.—*Annales de Chimie et de Phys.* several volumes.

ACID (MECONIC). This acid is a constituent of opium. It was discovered by M. Sertuerner, who procured it in the following way: After precipitating the *morphia*, from a solution of opium, by ammonia, he added to the residual fluid a solution of the muriate of barytes. A precipitate is in this way formed, which is supposed to be a quadruple compound, of barytes, morphia, extract, and the meconic acid. The extract is removed by alcohol, and the barytes by sulphuric acid; when the meconic acid is left, merely in combination with a portion of the morphia; and from this it is purified by successive solutions and evaporations. The acid, when sublimed, forms long colourless needles; it has a strong affinity for the oxide of iron, so as to take it from the muriatic solution, and form with it a cherry-red precipitate. It forms a crystallizable salt with lime, which is not decomposed by sulphuric acid; and what is curious, it seems to possess no particular power over the human body, when received into the stomach. The essential salt of opium, obtained in M. Derosne's original experiments, was probably the meconiate of morphia.

Mr. Robiquet has made a useful modification of the process for extracting meconic acid. He treats the opium with magnesia, to separate the morphia, while meconiate of magnesia is also formed. The magnesia is removed by adding muriate of barytes, and the barytes is afterwards separated by dilute sulphuric acid. A larger proportion of moconic acid is thus obtained.

Mr. Robiquet denies that meconic acid precipitates iron from the muriate; but, according to M. Vogel, its power of reddening solutions of iron is so great, as to render it a more delicate test of this metal, than even the ferroprussiate of potash.

To obtain pure meconic acid from the meconiate of barytes, M. Choulant triturated it in a mortar, with its own weight of glassy boracic acid. This mixture being put into a small glass flask, which was surrounded with sand in a sand pot, in the usual manner, and the red heat being gradually raised, the *meconic* acid sublimed in the state of fine white scales or plates. It has a strong sour taste, which leaves behind it an impression of bitterness. It dissolves readily in water, alcohol, and ether. It reddens the greater number of vegetable blues, and changes the solutions of iron to a cherry-red colour. When these solutions are heated, the iron is precipitated in the state of protoxide.

The *meconiates* examined by Choulant, are the following:—

1*st*, Meconiate of potash. It crystallizes in four-sided tables, is soluble in twice its weight of water, and is composed of

Meconic acid,	27	2.7
Potash,	60	6.0
Water,	13	
	100	

It is destroyed by heat.

2*d*, Meconiate of soda. It crystallizes in soft prisms, is soluble in five times its weight of water, and seems to effloresce. It is destroyed by heat. It consists of

Acid,	32	3.2
Soda,	40	4.0
Water,	28	
	100	

3*d*, Meconiate of ammonia. It crystallizes in star-form needles, which, when sublimed, lose their water of crystallization, and assume the shape of scales. The crystals are soluble in 1½ their weight of water, and are composed of

Acid,	40	2.03
Ammonia,	42	2.13
Water,	18	
	100	

If two parts of sal ammoniac be triturated with three parts of meconiate of barytes, and heat be applied to the mixture, meconiate of ammonia sublimes, and muriate of barytes remains.

4*th*, Meconiate of lime. It crystallizes in prisms, and is soluble in eight times its weight of water. It consists of

Acid,	34	2.882
Lime,	42	3.560
Water,	24	
	100	

As the potash and lime compounds give nearly the same acid ratio, we may take their mean of it as the true prime = 2.8.

To procure meconiate of morphia, says Dr. Giuseppe Meneci, reduce good opium to powder, put it into a paper filter, and distilled water to it, and slightly agitate it. In this way wash it, till the water passes through colourless; then pass a little diluted alcohol through it; dry the insoluble portion (now diminished to one half) in a dark place; digest it when dry in strong alcohol for a few minutes, applying heat; separate the solution, which, by cooling and after evaporation, will yield well-crystallized meconiate of morphia of a pale straw colour. *Giorn. di Fisica*, viii. 218.

ACID (MELASSIC). The acid present in melasses, which has been thought a peculiar acid by some, by others, the acetic.

ACID (MELLITIC). M. Klaproth discovered in the melilite, or honey-stone, what he conceives to be a peculiar acid of the vegetable kind, combined with alumina. This acid is easily obtained by reducing the stone to powder, and boiling it in about 70 times its weight of water; when the acid will dissolve, and may be separated from the alumina by filtration. By evaporating the solution, it may be obtained in the form of crystals. The following are its characters:—

It crystallizes in fine needles or globules by the union of these, or small prisms. Its taste is at first a sweetish-sour, which leaves a bitterness behind. On a plate of hot metal it is readily decomposed, and dissipated in copious grey fumes, which affect not the smell, leaving behind a small quantity of ashes, that do not change either red or blue tincture of litmus. Neutralized by potash it crystallizes in groups of long prisms: by soda, in cubes, or triangular laminæ, sometimes in groups, sometimes single; and by ammonia, in beautiful prisms with six planes, which soon lose their transparency, and acquire a silvery-white hue. If the mellitic acid be dissolved in lime water, and a solution of calcined strontian or barytes be dropped into it, a white precipitate is thrown down, which is redissolved on adding muriatic acid. With a solution of acetate of barytes, it produces likewise a white precipitate, which nitric acid redissolves. With solution of muriate of barytes, it produces no precipitate, or even cloud; but after standing some time, fine transparent needly crystals are deposited. The mellitic acid produces no change in a solution of nitrate of silver. From a solution of nitrate of mercury, either hot or cold, it throws down a copious white precipitate, which an addition of nitric acid immediately redissolves. With nitrate of iron it gives an abundant precipitate of a dun yellow colour, which may be redissolved by muriatic acid. With a solution of acetate of lead, it produces an abundant precipitate, immediately redissolved on adding nitric acid. With acetate of copper, it gives a greyish-green precipitate; but it does not affect a solution of muriate of copper. Lime water precipitated by it, is immediately redissolved on adding nitric acid.

M. Klaproth was never able to convert this acid into the oxalic by means of nitric acid, which only changed its brownish colour to a pale yellow.

The *mellite*, or native mellate of alumina, consists, according to Klaproth, of 46 acid + 16 alumina + 38 water = 100; from which, calling the prime of alumina 2.25, that of mellitic acid appears to be 6.5.

ACID (MENISPERMIC). The seeds of *menispermum cocculus* being macerated for 24 hours in 5 times their weight of water, first cold, and then boiling hot, yield an infusion, from which solution of subacetate of lead throws down a menispermate of lead. This is to be washed and drained, diffused through water, and decomposed by a current of sulphuretted hydrogen gas. The liquid thus freed from lead, is to be deprived of sulphuretted hydrogen by heat, and then forms solution of menispermic acid. By repeated evaporations and solutions in alcohol, it loses its bitter taste, and becomes a purer acid. It occasions no precipitate with lime water; with nitrate of barytes it yields a grey precipitate; with nitrate of silver, a deep yellow; and with sulphate of magnesia, a copious precipitate.

M. J. L. Casaseca has published in the 30th volume of the Annales de Chimie et de

Physique, a Memoir on Menispermum Cocculus, in which he comes to the following conclusions:—

1. That menispermic acid does not exist.

2. That picrotoxia does not possess alkaline properties, and ought not to be considered as a new vegetable salifiable base, but merely as a peculiar bitter principle, as M. Boullay announced it in his first paper.

ACID (MOLYBDIC). The native sulphuret of molybdenum being roasted for some time, and dissolved in water of ammonia, when nitric acid is added to this solution, the molybdic acid precipitates in fine white scales, which become yellow on melting and subliming them. It changes the vegetable blues to red, but less readily and powerfully than the molybdous acid.

M. Bucholz found that 100 parts of the sulphuret gave 90 parts of molybdic acid. In other experiments in which he oxidized molybdenum, he found that 100 of the metal combined with from 49 to 50 of oxygen. Berzelius, after some vain attempts to analyse the molybdates of lead and barytes, found that the only method of obtaining an exact result was to form a molybdate of lead. He dissolved 10 parts of neutral nitrate of lead in water, and poured an excess of solution of crystallized molybdate of ammonia into the liquid. The molybdate of lead, washed, dried, and heated to redness, weighed 11.068. No traces of lead were found in the liquid by sulphate of ammonia; hence these 11.068 of lead, evince 67.3 per cent. of oxide of lead. This salt then is composed of

Molybdic acid,	39.194	9.0
Oxide of lead,	60.806	14.0
	100.000	

And from Bucholz we infer, that this prime equivalent 9, consists of 3 of oxygen + 6 metal; while molybdous acid will be 2 oxygen + 6 metal = 8.0.

Molybdic acid has a specific gravity of 3.460. In an open vessel it sublimes into brilliant yellow scales; 960 parts of boiling water dissolve one of it, affording a pale yellow solution, which reddens litmus, but has no taste. Sulphur, charcoal, and several metals decompose the molybdic acid. Molybdate of potash is a colourless salt. Molybdic acid gives, with nitrate of lead, a white precipitate, soluble in nitric acid; with the nitrates of mercury and silver, a white flaky precipitate; with nitrate of copper, a greenish precipitate; with solutions of the *neutral* sulphate of zinc, muriate of bismuth, muriate of antimony, nitrate of nickel, muriates of gold and platinum, it produces white precipitates. When melted with borax, it yields a bluish colour; and paper dipped in its solution becomes, in the sun, of a beautiful blue.

The neutral alkaline molybdates precipitate all metallic solutions. Gold, muriate of mercury, zinc, and manganese, are precipitated in the form of a white powder; iron and tin, from their solutions in muriatic acid, of a brown colour; cobalt, of a rose colour; copper, blue; and the solutions of alum and quicklime, white. If a dilute solution of recent muriate of tin be precipitated by a dilute solution of molybdate of potash, a beautiful blue powder is obtained.

The concentrated sulphuric acid dissolves a considerable quantity of the molybdic acid, the solution becoming of a fine blue colour as it cools, at the same time that it thickens; the colour disappears again on the application of heat, but returns again by cooling. A strong heat expels the sulphuric acid. The nitric acid has no effect on it; but the muriatic dissolves it in considerable quantity, and leaves a dark blue residuum when distilled. With a strong heat it expels a portion of sulphuric acid from sulphate of potash. It also disengages the acid from nitre and common salt by distillation. It has some action upon the filings of the metals in the moist way.

The molybdic acid has not yet been employed in the arts.

ACID (MOLYBDOUS). The deutoxide of molybdenum is of a blue colour, and possesses acid properties. Triturate 2 parts of molybdic acid, with 1 part of the metal, along with a little hot water, in a porcelain mortar, till the mixture assumes a blue colour. Digest in 10 parts of boiling water, filter, and evaporate the liquid in a heat of about 120°. The blue oxide separates. It reddens vegetable blues, and forms salts with the bases. Air or water, when left for some time to act on molybdenum, converts it into this acid. It consists of about 100 metal to 34 oxygen.

ACID (MOROXYLIC). In the botanic garden at Palermo, Mr. Thompson found an uncommon saline substance on the trunk of a white mulberry tree. It appeared as a coating on the surface of the bark in little granulous drops of a yellowish and blackish-brown colour, and had likewise penetrated its substance. M. Klaproth, who analyzed it, found that its taste was somewhat like that of succinic acid; on burning coals it swelled up a little, emitted a pungent vapour scarcely visible to the eye, and left a slight earthy residuum. Six hundred grains of the bark loaded with it were lixiviated with water, and afforded 320 grains of a light salt, resembling in colour a light wood, and composed of short needles united in radii. It was not deliquescent; and though the crystals did not form till the solution was greatly condensed by evaporation, it is not very soluble, since 1000 parts of water dissolve but 35 with heat, and 15 in the cold.

This salt was found to be a compound of lime and a peculiar vegetable acid, with some extractive matter.

To obtain the acid separate, M. Klaproth decomposed the calcareous salt by acetate of lead, and separated the lead by sulphuric acid. He likewise decomposed it directly by sulphuric acid. The product was still more like succinic acid in taste; was not deliquescent; easily dissolved both in water and alcohol; and did not precipitate the metallic solutions, as it did in combination with lime. Twenty grains being slightly heated in a small glass retort, a number of drops of an acid liquor first came over; next a concrete salt arose, that adhered flat against the top and part of the neck of the retort in the form of prismatic crystals, colourless and transparent; and a coaly residuum remained. The acid was then washed out, and crystallized by spontaneous evaporation.—Thus sublimation appears to be the best mode of purifying the salt, but it adhered too strongly to the lime to be separated from it directly by heat without being decomposed.

Not having a sufficient quantity to determine its specific characters, though he conceives it to be a peculiar acid, coming nearest to the succinic both in taste and other qualities, M. Klaproth has provisionally given it the name of moroxylic, and the calcareous salt containing it that of moroxylate of lime.

ACID (MUCIC). This acid has been generally known by the name of *saccholactic*, because it was first obtained from sugar of milk; but as all the gums appear to afford it, and the principal acid in sugar of milk is the oxalic, chemists in general now distinguish it by the name of *mucic* acid.

It was discovered by Scheele. Having poured twelve ounces of diluted nitric acid on four ounces of powdered sugar of milk in a glass retort on a sand bath, the mixture became gradually hot, and at length effervesced violently, and continued to do so for a considerable time after the retort was taken from the fire. It is necessary therefore to use a large retort, and not to lute the receiver too tight. The effervescence having nearly subsided, the retort was again placed on the sand heat, and the nitric acid distilled off, till the mass had acquired a yellowish colour. This exhibiting no crystals, eight ounces more of the same acid were added, and the distillation repeated, till the yellow colour of the fluid disappeared. As the fluid was inspissated by cooling, it was redissolved in eight ounces of water, and filtered. The filtered liquor held oxalic acid in solution, and seven drams and a half of white powder remained on the filter. This powder was the acid under consideration.

If one part of gum be heated gently with two of nitric acid, till a small quantity of nitrous gas and of carbonic acid is disengaged, the dissolved mass will deposit on cooling the mucic acid. According to Fourcroy and Vauquelin, different gums yield from 14 to 26 hundredths of this acid.

This pulverulent acid is soluble in about 60 parts of hot water, and by cooling, a fourth part separates in small shining scales, that grow white in the air. It decomposes the muriate of barytes, and both the nitrate and muriate of lime. It acts very little on the metals, but forms with their oxides salts scarcely soluble. It precipitates the nitrates of silver, lead, and mercury. With potash it forms a salt soluble in eight parts of boiling water, and crystallizable by cooling. That of soda requires but five parts of water, and is equally crystallizable. Both these salts are still more soluble when the acid is in excess. That of ammonia is deprived of its base by heat. The salts of barytes, lime, and magnesia, are nearly insoluble.

Mucic or saccholactic acid has been analyzed recently with much care:

	Hydrogen.	Carbon.	Oxygen.	
By Lussac,	3.62	+33.69	+62.69	=100
Berzelius,	5.105	+33.430	+61.465	=100

From saclactate of lead, Berzelius has inferred the prime equivalent of the acid to be 13.1.

ACID (MURIATIC), the HYDROCHLORIC of the French chemists. Let 6 parts of pure and well dried sea salt be put into a glass retort, to the beak of which is luted, in a horizontal direction, a long glass tube artificially refrigerated, and containing a quantity of ignited muriate of lime. Upon the salt pour at intervals 5 parts of concentrated oil of vitriol, through a syphon funnel, fixed airtight, in the tubulure of the retort. The free end of the long tube being recurved, so as to dip into the mercury of a pneumatic trough, a gas will issue, which on coming in contact with the air, will form a visible cloud, or haze, presenting, when viewed in a vivid light, prismatic colours. This gas is muriatic acid.

When received in glass jars over dry mercury, it is invisible, and possesses all the mechanical properties of air. Its odour is pungent and peculiar. Its taste acid and corrosive. Its specific gravity, according to Sir H. Davy, is such, that 100 cubic inches weigh 39 grains, while by estimation, he says, they ought to be 38.4 gr. By the latter number the specific gravity, compared to air, becomes 1.2590. By the former number the density comes out 1.2800. M. Gay Lussac states the sp. gr. at 1.2780. Sir H.'s second number makes the prime equivalent of chlorine 4.43, which comes near to Berzelius's latest result; while his first number makes it 4.48. (See CHLORINE). As the attraction of muriatic acid gas for hygrometric water is very strong, it is very probable that 38.4 grs. may be the more exact weight of 100 cubic inches, regarding the same bulk of air as = 30.5. (See the table of GASES.) If an inflamed taper be immersed in it, it is instantly extinguished. It is destructive of animal life; but the irritation produced by it on the epiglottis scarcely permits its descent into the lungs. It is merely changed in bulk by alterations of temperature; it experiences no change of state.

By sealing up muriate of ammonia and sulphuric acid in a strong glass tube recurved, and causing them to act on each other, Sir H. Davy procured liquid muriatic acid. He justly observes, that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating their molecules than those dependent on the application of cold, whether natural or artificial; for as gases diminish only $\frac{1}{480}$ in volume for every degree of Fahrenheit's scale beginning at ordinary temperature, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature: and when attempts are made to condense gases into liquids by sudden mechanical compression, the heat instantly generated presents a formidable obstacle to the success of the experiment; whereas in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger; and it may be easily assisted by artificial cold in cases where gases approach near to that point of compression and temperature at which they become vapours. *Phil. Trans.* 1823.

When potassium, tin, or zinc, is heated in contact with this gas over mercury, one-half of the volume disappears, and the remainder is pure hydrogen. On examining the solid residue, it is found to be a metallic chloride. Hence muriatic acid gas consists of chlorine and hydrogen, united in equal volumes. This view of its nature was originally given by Scheele, though obscured by terms derived from the vague and visionary hypothesis of phlogiston. The French school afterwards introduced the belief that muriatic acid gas was a compound of an unknown radical and water; and that chlorine consisted of this radical and oxygen. Sir H. Davy has the distinguished glory of refuting that hypothesis, and of proving by decisive experiments, that in the present state of our knowledge, chlorine must be regarded as a simple substance; and muriatic acid gas as a compound of it with hydrogen.

This gaseous acid unites rapidly, and in large quantity, with water. The following table of its aqueous combinations was constructed after experiments made by Mr. E. Davy, in the laboratory of the Royal Institution, under the inspection of Sir H. Davy.

At temperature 45°, barometer 30.

100 parts of solution of muriatic gas in water, of specific gravity		Of muriatic acid gas, parts.
1.21	contain	42.43
1.20		40.80
1.19		38.38
1.17		34.34
1.16		32.32
1.15		30.30
1.14	contain	28.28
1.13		26.26
1.12		24.24
1.11		22.30
1.10		20.20
1.09		18.18
1.08		16.16
1.07		14.14
1.06		12.12
1.05		10.10
1.04		8.08
1.03		6.06
1.02		4.04
1.01		2.02

At the temperature of 40° Fahrenheit, water absorbs about 480 times its bulk of gas, and forms solution of muriatic acid gas in water, the specific gravity of which is 1.2109.—*Sir H. Davy's Elements.*

In the Annals of Philosophy for October and November, 1817, there are two papers on the constitution of liquid muriatic acid, with tables, by myself, which coincide nearly with the preceding results. They were founded on a great number of experiments carefully performed, which are detailed in the October number. In mixing strong liquid acid with water, I found that some heat is evolved, and a small condensation of volume is experienced, contrary to the observation of Mr. Kirwan. Hence this acid forms no longer an exception, as that eminent chemist taught, to the general law of condensation of volume which liquid acids obey in their progressive dilutions. Hitherto, indeed, many chemists have, without due consideration, assumed the half sum or *arithmetical* mean of two specific gravities, to be the truly *computed* mean; and on comparing the number thus obtained with that derived from experiment, they have inferred the change of volume occasioned by chemical combination. The errors into which this false mode of computation leads are excessively great, when the two bodies differ considerably in their specific gravities. A view of these erroneous results was given in my third table of sulphuric acid, published in the 7th number of the Journal of Sciences and the Arts, and reprinted in this Dictionary, article SPECIFIC GRAVITY. When, however, the two specific gravities do not differ much, the errors become less remarkable. It is a singular fact, that the *arithmetical* mean, which is always *greater* than the rightly *computed* mean specific gravity, gives, in the case of liquid muriatic acid, an error in excess, very nearly equal to the actual increase of density. The curious coincidence thus accidentally produced, between accurate experiments and a false mode of calculation, is very instructive, and ought to lead chemists to verify every anomalous phenomenon, by independent modes of research. Had Mr. Kirwan, for example, put into a nicely graduated tube 50 measures of strong muriatic acid, and poured gently over it 50 measures of water, he would have found after agitation, and cooling the mixture to its former temperature, that there was a decided diminution of volume, as I experimentally ascertained.

Having had occasion more lately to subject muriatic acid, in different states of dilution, to a very rigorous examination, I perceived small deviations in the new results from my former tabular quantities, which induced me to revise the whole with the greatest possible care, both in experiment and calculation. The following Table I believe to approach very near to the truth:

NEW TABLE of Muriatic Acid, *by* DR. URE.

Acid of 1.20 in 100.	Specific gravity.	Chlorine.	Muriatic Gas.	Acid of 1.20 in 100.	Specific gravity.	Chlorine.	Muriatic Gas.	Acid of 1.20 in 100.	Specific gravity.	Chlorine.	Muriatic Gas.
100	1.2000	39.675	40.777	66	1.1328	26.186	26.913	32	1.0637	12.697	13.049
99	1.1982	39.278	40.369	65	1.1308	25.789	26.505	31	1.0617	12.300	12.641
98	1.1964	38.882	39.961	64	1.1287	25.392	26.098	30	1.0597	11.903	12.233
97	1.1946	38.485	39.554	63	1.1267	24.996	25.690	29	1.0577	11.506	11.825
96	1.1928	38.089	39.146	62	1.1247	24.599	25.282	28	1.0557	11.109	11.418
95	1.1910	37.692	38.738	61	1.1226	24.202	24.874	27	1.0537	10.712	11.010
94	1.1893	37.296	38.330	60	1.1206	23.805	24.466	26	1.0517	10.316	10.602
93	1.1875	36.900	37.923	59	1.1185	23.408	24.058	25	1.0497	9.919	10.194
92	1.1857	36.503	37.516	58	1.1164	23.012	23.650	24	1.0477	9.522	9.786
91	1.1846	36.107	37.108	57	1.1143	22.615	23.242	23	1.0457	9.126	9.379
90	1.1822	35.707	36.700	56	1.1123	22.218	22.834	22	1.0437	8.729	8.971
89	1.1802	35.310	36.292	55	1.1102	21.822	22.426	21	1.0417	8.332	8.563
88	1.1782	34.913	35.884	54	1.1082	21.425	22.019	20	1.0397	7.935	8.155
87	1.1762	34.517	35.476	53	1.1061	21.028	21.611	19	1.0377	7.538	7.747
86	1.1741	34.121	35.068	52	1.1041	20.632	21.203	18	1.0357	7.141	7.340
85	1.1721	33.724	34.660	51	1.1020	20.235	20.796	17	1.0337	6.745	6.932
84	1.1701	33.328	34.252	50	1.1000	19.837	20.388	16	1.0318	6.348	6.524
83	1.1681	32.931	33.845	49	1.0980	19.440	19.980	15	1.0298	5.951	6.116
82	1.1661	32.535	33.437	48	1.0960	19.044	19.572	14	1.0279	5.554	5.709
81	1.1641	32.136	33.029	47	1.0939	18.647	19.165	13	1.0259	5.158	5.301
80	1.1620	31.746	32.621	46	1.0919	18.250	18.757	12	1.0239	4.762	4.893
79	1.1599	31.343	32.213	45	1.0899	17.854	18.349	11	1.0220	4.365	4.486
78	1.1578	30.946	31.805	44	1.0879	17.457	17.941	10	1.0200	3.968	4.078
77	1.1557	30.550	31.398	43	1.0859	17.060	17.534	9	1.0180	3.571	3.670
76	1.1536	30.153	30.990	42	1.0838	16.664	17.126	8	1.0160	3.174	3.262
75	1.1515	29.757	30.582	41	1.0818	16.267	16.718	7	1.0140	2.778	2.854
74	1.1494	29.361	30.174	40	1.0798	15.870	16.310	6	1.0120	2.381	2.447
73	1.1473	28.964	29.767	39	1.0778	15.474	15.902	5	1.0100	1.984	2.039
72	1.1452	28.567	29.359	38	1.0758	15.077	15.494	4	1.0080	1.588	1.631
71	1.1431	28.171	28.951	37	1.0738	14.680	15.087	3	1.0060	1.191	1.224
70	1.1410	27.772	28.544	36	1.0718	14.284	14.679	2	1.0040	0.795	0.816
69	1.1389	27.376	28.136	35	1.0697	13.887	14.271	1	1.0020	0.397	0.408
68	1.1369	26.979	27.728	34	1.0677	13.490	13.863				
67	1.1349	26.583	27.321	33	1.0657	13.094	13.456				

At the density 1.199, Mr. Dalton's table* has 25.6 per cent. of real muriatic acid by weight, equivalent to only 32.9 chlorine, instead of 39.47, which I believe to be the exact value. If we term the correct quantity 100, then Mr. Dalton's number would be only 83; which is no less than 17 per cent. of defect from the truth. I have purposely omitted in this new table the column of dry, or, as it was also called, real muriatic acid; first, because there is no evidence at present of the existence of any such body; and secondly, because, though it was a convenient column for finding by inspection the increase of weight which any salifiable base would acquire by saturation with the liquid acid, yet that convenience may be obtained by the following simple calculation. Since the prime equivalent of chlorine is to that of the supposed dry muriatic acid in the ratio of 45 to 35, or 9 to 7; if we multiply the number opposite to the given specific gravity, in the chlorine column, by 9, and divide by 7, we shall have the relative quantity of the *fixable* muriatic acid.—*Journ. of Science*, xii. 267.

From the curious coincidence above noticed, we derive a very simple rule for finding the approximate value of chlorine in the liquid acid at any density. Multiply the decimal part of the number representing the specific gravity by 200, the product will be the chlorine present in 100 parts. Thus, the specific gravity is 1.0437, what is the quantity per cent. of chlorine? 0.0437 × 200 = 8.74. Now the tabular number is 8.729. The sp. gravity being 1.059, what is the value of the chlorine in 100 parts? $0.059 \times 200 = 11.8$. The table has 11.9. Towards the head of the table this rule gives a slight error in excess; and towards the foot an equally slight error in defect, but the approximation is always good enough for ordinary practice, seldom amounting to one-half per cent. If to the number thus found for chlorine we add $\frac{1}{35}$ part, the sum is the corresponding weight of muriatic acid gas.

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* New System of Chemical Philosophy, ii. p. 295.

We have seen it stated, that water, in absorbing 480 times its bulk of the acid gas, becomes of specific gravity 1.2109. If we compute from these *data* the increase of its *bulk*, we shall find it equal to 1.42, or nearly one and a half the volume of the water. 481 parts occupy only 1.42 in bulk, a condensation of about 340 into one. The consequence of this approximation of the particles is the evolution of their latent heat; and accordingly the heat produced in the condensation of the gas is so great, that it melts ice almost as rapidly as the steam of boiling water does. Hence also in passing the gas from the beak of a retort into a Woolfe's apparatus containing water to be impregnated, it is necessary to surround the bottles with cold water or ice, if we wish a considerable condensation.

By uniting the base of this gas with silver, and also with potassium, Berzelius determined the prime equivalent of muriatic acid to be 3.4261, whence chlorine comes out 4.4261, and muriatic gas $4.4261 + 0.125$ (the prime of hydrogen) $= 4.5511$. But if we take 1.2847 as the specific gravity of this acid gas, then the specific gravity of chlorine will be twice that number, *minus* the specific gravity of hydrogen, or $(1.2847 \times 2) - 0.0694 = 2.5$; and as chlorine and hydrogen unite volume to volume, then the relation of the prime of chlorine will be to that of hydrogen $= \frac{2.5}{0.0694} = 36$. If we divide this by 8, we shall have 4.5 to represent the prime equivalent of chlorine, and $4.5 + 0.125 = 4.625$ for that of muriatic acid gas.

Muriatic acid, from its composition, has been termed by M. Gay Lussac the hydrochloric acid; a name objected to on good grounds by Sir H. Davy. It was prepared by the older chemists in a very rude manner, and was called by them spirit of salt.

Muriatic was anciently extracted from common salt, by igniting a mixture of it and soft clay kneaded up together.

Sir H. Davy first gave the just explanation of this decomposition. Common salt is a compound of sodium and chlorine. The sodium may be conceived to combine with the oxygen of the water in the earth, and with the earth itself, to form a vitreous compound; and the chlorine to unite with the hydrogen of the water, forming muriatic acid gas. "It is also easy," adds he, "according to these new ideas, to explain the decomposition of salt by moistened litharge, the theory of which has so much perplexed the most acute chemists. It may be conceived to be an instance of compound affinity; the chlorine is attracted by the lead, and the sodium combines with the oxygen of the litharge, and with water, to form hydrate of soda, which gradually attracts carbonic acid from the air. When common salt is decomposed by oil of vitriol, it was usual to explain the phenomenon by saying, that the acid by its superior affinity, aided by heat, expelled the gas, and united to the soda. But as neither muriatic acid nor soda exists in common salt, we must now modify the explanation, by saying that the water of the oil of vitriol is first decomposed, its oxygen unites to the sodium to form soda, which is seized on by the sulphuric acid, while the chlorine combines with the hydrogen of the water, and exhales in the form of muriatic acid gas."

As 100 parts of dry sea salt are capable of yielding 62 parts by weight of muriatic acid gas, these ought to afford, by economical management, nearly 221 parts of liquid acid, specific gravity 1.142, as prescribed by the London College, or 200 parts of acid sp. gr. 1.160, as directed by the Edinburgh and Dublin Pharmacopœias.

The fluid ounce of the London College being $\frac{1}{16}$ of a wine pint, is equal in weight to 1.265817 lbs. Troy divided by 16, which gives 453.7 grains Troy. This weight multiplied by $1.142 =$ the specific gravity of their standard acid, gives the product 520.4; which being multiplied by 0.2874, the muriatic gas in 1.00 by my table, we have 149.56 for the acid gas in the liquid ounce of the above density. We find this quantity equivalent to 203 gr. of carbonate of lime. When this acid is contaminated with sulphuric acid, it affords precipitates with muriates of barytes and strontites.

The English manufacturers use iron stills for this distillation, with earthen heads.

The muriates, when in a state of dryness, are actually chlorides, consisting of chlorine and the metal; yet they may be conveniently treated of under the title muriates.

The muriate of barytes crystallizes in tables bevelled at the edges, or in octaëdral pyramids applied base to base. It is soluble in five parts of water at 60°, in still less at a boiling heat, and also in alcohol. It is not altered in the air, and but partly decomposable by heat. The sulphuric acid separates its base; and the alkaline carbonates and sulphates decompose it by double affinity. It is best prepared by dissolving the carbonate in dilute muriatic acid; and if contaminated with iron or lead, which occasionally happens, these may be separated by the addition of a small quantity of liquid ammonia, or by boiling and stirring the solution with a little barytes. Mr. Goettling recommends to prepare it from the sulphate of barytes; eight parts of which in fine powder are to be mixed with two of muriate of soda, and one of charcoal powder. This is to be pressed hard into a Hessian crucible, and exposed for an hour and a half to a red heat in a wind furnace. The cold mass, being powdered, is to be boiled a minute or two in sixteen parts of water, and then filtered. To this liquor muriatic acid is to be added by little and little, till sulphuretted hydrogen ceases to be evolved; it is then to be filtered, a little hot water to be poured on the residuum, the liquor evaporated to a pellicle, filtered again, and then set to crystallize. As the muriate of soda is much more soluble than the muriate of barytes, and does not separate by cooling, the muriate of barytes will crystallize into a perfectly white salt, and leave the muriate of soda in the mother water, which may be evaporated repeatedly till no more muriate of barytes is obtained. This salt was first employed in medicine by Dr. Crawford, chiefly in scrofulous complaints and cancer, beginning with doses of a few drops of the saturated solution twice a-day, and increasing it gradually, as far as forty or fifty drops in some instances. In large doses it excites nausea, and has deleterious effects. As a test of sulphuric acid it is of great use.

Mr. Phillips states the composition of the crystals to be an atom chloride of barium + 2 atoms water.

The muriate of potash, formerly known by the names of *febrifuge salt of Sylvius*, crystallizes in regular cubes, or in rectangular parallelopipedons; decrepitating on the fire. Their taste is saline and bitter. They are soluble in thrice their weight of cold water, and in but little less of boiling water, so as to require spontaneous evaporation for crystallizing. Fourcroy recommends, to cover the vessel with gauze, and suspend hairs in it, for the purpose of obtaining regular crystals.

It is sometimes prepared in decomposing sea salt by common potash for the purpose of obtaining soda; and may be formed by the direct combination of its constituent parts.

Muriate of soda, or *common salt*, is of considerable use in the arts, as well as a necessary ingredient in our food. It crystallizes in cubes, which are sometimes grouped together in various ways, and not unfrequently form hollow quadrangular pyramids. In the fire it decrepitates, melts, and is at length volatilized. When pure it is not deliquescent. One part is soluble in 2½ of cold water, and in little less of hot, so that it cannot be crystallized but by evaporation.

Common salt is found in large masses, or in rocks under the earth, in England and elsewhere. In the solid form it is called *sal gem*, or *rock salt*. This rock salt is never used on our tables in its crude state, as the Polish rock salt is.

The waters of the ocean everywhere abound with common salt, though in different proportions. The water of the Baltic sea is said to contain one sixty-fourth of its weight of salt; that of the sea between England and Flanders contains one thirty-second part; and that on the coast of Spain one sixteenth part.

The whole art of extracting salt from waters which contain it consists in evaporating the water in the cheapest and most convenient manner.

There is no difference between this salt and the lake salt extracted from different lakes, excepting such as may be occasioned by the casual intervention of some substances.

At several places in Germany, and at Montmarot in France, the waters of salt springs are pumped up to a large reservoir at the top of a building or shed; from which it drops or trickles through small apertures upon boards covered with brushwood. The large surface of the water thus exposed to the air causes a very considerable evaporation; and the brine is afterward conveyed to the boilers for the perfect separation of the salt.

To free common salt from those mixtures that render it deliquescent, and less fit for the purposes to which it is applied, it may be put into a conical vessel with a small aperture at the point, and a saturated solution of the muriate of soda boiling hot be poured on it. This solution will dissolve and carry off any other salts mixed with the soda, and leave it quite pure, by repeating the process three or four times.

At present, the greater part of the carbonate of soda in the market is furnished by decomposing the sulphate of soda left, after the chlorine is expelled in the usual way of eliminating it from common salt. Mix the sulphate of soda with an equal weight of chalk and rather more than half its weight of charcoal powder, and expose the mixture in a reverberatory furnace to a heat sufficient to bring them to a state of imperfect liquefaction. Much of the sulphur formed will be expelled in vapour and burned, the mixture being frequently stirred to promote this; and this is continued till the mass on cooling assumes a fine grain. It is then left exposed to a humid atmosphere, and the carbonate of soda may be extracted by lixiviation, the sulphur not consumed having united with the lime.

Beside its use in seasoning our food, and preserving meat both for domestic consumption and during the longest voyages, and in furnishing us with the muriatic acid and soda, salt forms a glaze for coarse pottery, by being thrown into the oven where it is baked; it improves the whiteness and clearness of glass; it gives hardness to soap; in melting metals it preserves their surface from calcination, by defending them from the air, and is employed with advantage in some assays; it is used as a mordant, and for improving certain colours, and enters more or less into many other processes of the arts.

The muriate of strontian crystallizes in very slender hexagonal prisms, has a cool pungent taste, without the austerity of the muriate of barytes, or the bitterness of the muriate of lime; is soluble in 0.75 of water at 60°, and to almost any amount in boiling water; is likewise soluble in alcohol, and gives a blood-red colour to its flame.

It has never been found in nature, but may be prepared in the same way as the muriate of barytes.

The muriate of lime crystallizes in hexaëdral prisms terminated by acute pyramids; but if the solution be greatly concentrated, and exposed to a low temperature, it is condensed in confused bundles of needly crystals. Its taste is acrid, bitter, and very disagreeable. It is soluble in half its weight of cold water, and by heat in its own water of crystallization. It is one of the most deliquescent salts known; and when deliquesced has been called *oil of lime*. It exists in nature, but neither very abundantly nor very pure. It is formed in chemical laboratories, in the decomposition of muriate of ammonia; and Homberg found, that if it were urged by a violent heat till it condensed, on cooling, into a vitreous mass, it emitted a phosphoric light upon being struck by any hard body; in which state it was called *Homberg's phosphorus*.

The muriate of ammonia has long been known by the name of *sal ammonia*, or *ammoniac*. It is found native in the neighbourhood of volcanoes, where it is sublimed sometimes nearly pure, and in different parts of Asia and Africa. A great deal is carried annually to Russia and Siberia from Bucharian Tartary; and we formerly imported large quantities from Egypt, but now manufacture it at home. See AMMONIA.

This salt is usually in the form of cakes, with a convex surface on one side, and concave on the other, from being sublimed into large globular vessels; but by solution it may be obtained in regular quadrangular crystals. It is remarkable for possessing a certain degree of ductility, so that it is not easily pulverable. It is soluble in 3½ parts of water at 60°, and in little more than its own weight of boiling water. Its taste is cool, acrid, and bitterish. Its specific gravity is 1.42. It attracts moisture from the air but very slightly.

In tinning and soldering, it is employed to preserve the surface of the metals from oxidation. In assaying, it discovers iron, and separates it from some of its combinations.

The muriate of magnesia is extremely deliquescent, soluble in an equal weight of water, and difficultly crystallizable. It dissolves also in five parts of alcohol. It is decomposable by heat, which expels its acid. Its taste is intensely bitter.

With ammonia this muriate forms a triple salt, crystallizable in little polyedrons, which separate quickly from the water, but are not very regularly formed. Its taste partakes of that of both the preceding salts. The best mode of preparing it is by mixing a solution of 27 parts of muriate of ammonia with a solution of 73 of muriate of magnesia; but it may be formed by a semi-decomposition of either of these muriates by the base of the other. It is decomposable by heat, and requires six or seven times its weight of water to dissolve it.

The muriate of glucine appears to crystallize in very small crystals; to be decomposable by heat; and, dissolved in alcohol and diluted with water, to form a pleasant saccharine liquor.

Muriate of alumina is scarcely crystallizable, as on evaporation it assumes the state of a thick jelly. It has an acid, styptic, acrid taste. It is extremely soluble in water, and deliquescent. Fire decomposes it. It may be prepared by directly combining the muriatic acid with alumina, but the acid always remains in excess.

The muriate of zircon crystallizes in small needles, which are very soluble, attract moisture, and lose their transparency in the air. It has an austere taste, with somewhat of acrimony. It is decomposable by heat. The gallic acid precipitates from its solution, if it be free from iron, a white powder. Carbonate of ammonia, if added in excess, redissolves the precipitate it had before thrown down.

Muriate of yttria does not crystallize when evaporated, but forms a jelly: it dries with difficulty, and deliquesces. See SALT.

ACID (MURIATIC, OXYGENATED). See CHLORINE.

* ACID (MURIATIC, OXYGENIZED). This supposed acid was lately described by M. Thenard. He saturated common muriatic acid of moderate strength with deutoxide of barium, reduced into a soft paste by trituration with water. He then precipitated the barytes from the liquid, by adding the requisite quantity of sulphuric acid. He next took this oxygenized muriatic acid, and treated it with deutoxide of barium and sulphuric acid, to oxygenate it anew. In this way he charged it with oxygen as often as 15 times. He thus obtained a liquid acid which contained 32 times its volume of oxygen at the temperature of 68° Fahr. and at the ordinary atmospherical pressure, and only 4½ times its volume of muriatic acid, which gives about 28 equivalent primes of oxygen to one of muriatic acid. For the ratio of oxygen to the acid, by weight, is 1 to 4.6; but by measure the ratio will be as these two numbers respectively divided by the specific gravity of the gases, or as $\frac{1}{1.111}$ to $\frac{4.6}{1.278}$, which by reduction makes nearly one volume of oxygen, equivalent to four of muriatic acid. Now, the oxygen in the above result, instead of being 1-4th of the volume of the acid gas, was seven times greater, whence we derive the number 28. Still more oxygen may however be added. On putting the above oxygenized acid in contact with sulphate of silver, an insoluble chlo-

ride of this metal subsides, and the liquid is oxygenized sulphuric acid. When this is passed through the filter, muriatic acid is added to it, but in smaller quantity than existed in the original oxygenized acid. A quantity of barytes, just sufficient to precipitate the sulphuric acid, is then added. Instantly the oxygen, leaving the sulphuric acid to unite with the muriatic acid, brings that acid to the highest point of oxygenation. Thus we see that we can transfer the whole of the oxygen from one of these acids to the other: and on a little reflection it will be evident, that to obtain sulphuric acid in the highest degree of oxygenation, it will be merely necessary to pour barytes water into oxygenated sulphuric acid, so as to precipitate only a part of the acid.

All these operations, with a little practice, may be performed without the least difficulty. By combining the two methods just described, M. Thenard found that he could obtain oxygenized muriatic acid, containing nearly 16 times as many volumes of oxygen as of muriatic acid, which represents about 64 equivalent primes of the former to one of the latter. This oxygenized acid leaves no residuum when evaporated. It is a very acid, colourless liquid, almost destitute of smell, and powerfully reddens turnsole. When boiled for some time, its oxygen is expelled. It dissolves zinc without effervescence. Its action on the oxide of silver is curious. These two bodies occasion as lively an effervescence as if an acid were poured upon a carbonate. Water and a chloride are formed, while the oxygen is evolved. This oxide enables us to determine the quantity of oxygen present in the oxygenized acid. Pour mercury into a graduated glass tube, leaving a small determinate space, which must be filled with the above acid, invert the tube in mercury, let up oxide of silver diffused in water; instantly the oxygen is separated.

We ought, however, to regard this apparent oxygenation of the acid, merely as the conversion of a portion of its combined water into deutoxide of hydrogen. The same explanation may be extended to the other oxygenized acids of M. Thenard. See WATER.

ACID (CHLORIC). We place this acid after the muriatic acid, because it has chlorine also for its base. It was first eliminated from the salts containing it by M. Gay Lussac, and described by him in his admirable memoir on iodine, published in the 91st volume of the *Annales de Chimie*. When a current of chlorine is passed for some time through a solution of barytic earth in warm water, a substance called hyperoxymuriate of barytes by its first discoverer, M. Chenevix, is formed, as well as some common muriate. The latter is separated, by boiling phosphate of silver in the compound solution. The former may then be obtained by evaporation, in fine rhomboidal prisms. Into a dilute solution of this salt, M. Gay Lussac poured weak sulphuric acid. Though he added only a few drops of acid, not nearly enough to saturate the barytes, the liquid became sensibly acid, and not a bubble of oxygen escaped. By continuing to add sulphuric acid with caution, he succeeded in obtaining an acid liquid entirely free from sulphuric acid and barytes, and not precipitating nitrate of silver. It was chloric acid dissolved in water. Its characters are the following.

This acid has no sensible smell. Its solution in water is perfectly colourless. Its taste is very acid, and it reddens litmus without destroying the colour. It produces no alteration on solution of indigo in sulphuric acid. Light does not decompose it. It may be concentrated by a gentle heat, without undergoing decomposition, or without evaporating. It was kept a long time exposed to the air without sensible diminution of its quantity. When concentrated, it has something of an oily consistency. When exposed to heat, it is partly decomposed into oxygen and chlorine, and partly volatilized without alteration. Muriatic acid decomposes it in the same way, at the common temperature. Sulphurous acid, and sulphuretted hydrogen, have the same property; but nitric acid produces no change upon it. Combined with ammonia, it forms a fulminating salt, formerly described by M. Chenevix. It does not precipitate any metallic solution. It readily dissolves zinc, disengaging hydrogen; but it acts slowly on mercury. It cannot be obtained in the gaseous state. It is composed of 1 volume chlorine + 2.5 oxygen, or, by weight, of 100 chlorine + 111.70 oxygen, if we consider the specific gravity of chlorine to be 2.4866. But if it be called 2.420, as M. Gay Lussac does in his memoir, it will then come out 100 chlorine + 114.7 oxygen. This last number is however too great, in consequence of estimating the specific gravity of oxygen 1.1111. while M. Gay Lussac makes it 1.10359. Chloric acid is at any rate a compound of 5 primes of oxygen + 1 of chlorine = 5. + 4.5.

M. Vauquelin, in making phosphate of silver act on the mixed saline solution above described, tried to accelerate its action by dissolving it previously in acetic acid. But on evaporating the chlorate of barytes so obtained to dryness, and exposing about 30 grains to a decomposing heat, a tremendous explosion took place, which broke the furnace, rent a thick platina crucible, and drove its lid into the chimney, where it stuck. It was the employment of acetic acid which occasioned this accident, and therefore it ought never to be used in this way.

To the preceding account of the properties of chloric acid, M. Vauquelin has added the following. Its taste is not only acid, but astringent, and its odour, when concentrated, is somewhat pungent. It differs from chlorine, in not precipitating gelatine. When paper stained with litmus is left for some time in contact with it, the colour is destroyed.

Mixed with muriatic acid, water is formed, and both acids are converted into chlorine. Sulphurous acid is converted into sulphuric, by taking oxygen from the chloric acid, which is consequently converted into chlorine.

Chloric acid combines with the bases, and forms the chlorates, a set of salts formerly known by the name of the hyperoxygenized muriates. They may be formed either directly by saturating the alkali or earth with the chloric acid, or by the old process of transmitting chlorine through the solutions of the bases, in Woolfe's bottles. In this case the water is decomposed. Its oxygen unites to one portion of the chlorine, forming chloric acid, while its hydrogen unites to another portion of chlorine, forming muriatic acid; and hence, chlorates and muriates must be contemporaneously generated, and must be afterwards separated by crystallization, or peculiar methods.

The chlorate of potash or hyperoxymuriate has been long known. When exposed to a red heat, 100 grains of this salt yield 38.88 of oxygen, and are converted into the chloride of potassium, or the dry muriate. This remainder of 61.12 grains consists of 32.19 potassium and 28.93 chlorine. But 32.19 potassium require 6.50 oxygen, to form the potash which existed in the original chlorate. Therefore, subtracting this quantity from 38.88, we have 32.38 for the oxygen combined with the chlorine, constituting 61.31 of chloric acid, to 38.69 of potash.

Chlorate of potash may be procured by receiving chlorine, as it is formed, into a solution of potash. When the solution is saturated, it may be evaporated gently, and the first crystals produced will be the salt desired; this crystallizing before the simple muriate, which is produced at the same time with it. Its crystals are in shining hexaëdral laminæ, or rhomboidal plates.

Its taste is cooling, and rather unpleasant. Its specific gravity is 2.0. 16 parts of water, at 60°, dissolve one of it, and 2½ of boiling water. The purest oxygen is extracted from this salt, by exposing it to a gentle red heat. One hundred grains yield about 115 cubic inches of gas. It consists of 9.5 chloric acid + 6 potash = 15.5, which is the prime equivalent of the salt. It is incapable of discharging vegetable colours; but the addition of a little sulphuric acid developes this property. So likewise a few grains of it, added to muriatic acid, give it this property.

The effects of this salt on inflammable bodies are very powerful. Rub two grains into powder in a mortar, add a grain of sulphur, mix them well by gentle trituration, then collect the powder into a heap, and press upon it suddenly and forcibly with the pestle, a loud detonation will ensue. If the mixture be wrapped in strong paper, and struck with a hammer, the report will be still louder. Five grains of the salt, mixed in the same manner with two and a half of charcoal, will be inflamed by strong trituration, especially if a grain or two of sulphur be added, but without much noise. If a little sugar be mixed with half its weight of the chlorate, and a little strong sulphuric acid poured on it, a sudden and vehement inflammation will ensue; but this experiment requires caution, as well as the following. To one grain of the powdered salt in a mortar, add half a grain of phosphorus; it will detonate, with a loud report, on the gentlest trituration. In this experiment the hand should be defended by a glove, and great care should be taken that none of the phosphorus get into the eyes. Phosphorus may be inflamed by it under water, putting into a wine glass one part of phosphorus and two of the chlorate, nearly filling the glass with water, and then pouring in, through a glass tube reaching to the bottom, three or four parts of sulphuric acid. This experiment, too, is very hazardous to the eyes. If olive or linseed oil be taken instead of phosphorus, it may be inflamed by similar means on the surface of the water. This salt should not be kept mixed with sulphur, or perhaps any inflammable substance, as in this state it has been known to detonate spontaneously.

Chlorate of soda may be prepared in the same manner as the preceding, by substituting soda for potash; but it is not easy to obtain it separate, as it is nearly as soluble as the muriate of soda, requiring only 3 parts of cold water. Vauquelin formed it, by saturating chloric acid with soda; 500 parts of the dry carbonate yielding 1100 parts of crystallized chlorate. It consists of 4 soda + 9.5 acid = 13.5, which is its prime equivalent. It crystallizes in square plates, produces a sensation of cold in the mouth, and a saline taste; is slightly deliquescent, and in its other properties resembles the chlorate of potash.

Barytes appears to be the next base in order of affinity for this acid. The best method of forming it is to pour hot water on a large quantity of this earth, and to pass a current of chlorine through the liquid kept warm, so that a fresh portion of barytes may be taken up as the former is saturated. This salt is soluble in about four parts of cold water, and less of warm, and crystallizes like the simple muriate. It may be obtained, however, by the agency of double affinity; for phosphate of silver boiled in the solution will decompose the simple muriate, and the muriate of silver and phosphate of barytes being insoluble, will both fall down and leave the chlorate in solution alone. The phosphate of silver employed in this process must be perfectly pure, and not the least contaminated with copper.

The chlorate of strontites may be obtained in the same manner. It is deliquescent, melts immediately in the mouth, and produces cold; is more soluble in alcohol than the simple muriate, and crystallizes in needles.

The chlorate of lime, obtained in a similar way, is extremely deliquescent, liquefies at a low heat, is very soluble in alcohol, produces much cold in solution, and has a sharp bitter taste.

Chlorate of ammonia is formed by double affinity, the carbonate of ammonia decomposing the earthy salts of this genus, giving up its carbonic acid to their base, and combining with their acid into chlorate of ammonia, which may be obtained by evaporation. It is very soluble both in water and alcohol, and decomposed by a moderate heat.

The chlorate of magnesia much resembles that of lime.

To obtain chlorate of alumina, M. Chenevix put some alumina, precipitated from the muriate, and well washed, but still moist, into a Woolfe's apparatus, and treated it as the other earths. The alumina shortly disappeared; and on pouring sulphuric acid into the liquor, a strong smell of chloric acid was perceivable; but on attempting to obtain the salt pure by means of phosphate of silver, the whole was decomposed, and nothing but chlorate of silver was found in the solution. M. Chenevix adds, however, that the aluminous salt appears to be very deliquescent, and soluble in alcohol. See SALT.

ACID (PERCHLORIC). If about 3 parts of sulphuric acid be poured on one of chlorate of potash in a retort, and after the first violent action is over, heat be gradually applied, to separate the deutoxide of chlorine, a saline mass will remain, consisting of bisulphate of potash and perchlorate of potash. By one or two crystallizations, the latter salt may be separated from the former. It is a neutral salt, with a taste somewhat similar to the common muriate of potash. It is very sparingly soluble in cold water, since at 60°, only $\frac{1}{55}$ is dissolved; but in boiling water it is more soluble. Its crystals are elongated octahedrons. It detonates feebly when triturated with sulphur in a mortar. At the heat of 412°, it is resolved into oxygen and muriate of potash, in the proportion of 46 of the former to 54 of the latter. Sulphuric acid, at 280°, disengages the perchloric acid. For these facts science is indebted to Count Von Stadion. It seems to consist of 7 primes of oxygen, combined with 1 of chlorine, or $7.0 + 4.5$. These curious discoveries have been lately verified by Sir H. Davy. The other perchlorates are not known.

Before leaving the acids of chlorine, we shall describe the ingenious method employed by Mr. Wheeler to procure chloric acid from the chlorate of potash. He mixed a warm solution of this salt with one of fluosilicic acid. He kept the mixture moderately hot for a few minutes, and to insure the perfect decomposition of the salt, added a slight excess of the acid. Aqueous solution of ammonia will show, by the separation of silica, whether any of the fluosilicic acid be left after the decomposition of the chlorate. Thus we can effect its complete decomposition. The mixture becomes turbid, and fluosilicate of potash is precipitated abundantly in the form of a gelatinous mass. The supernatant liquid will then contain nothing but chloric acid, contaminated with a small quantity of fluosilicic. This may be removed by the cautious addition of a small quantity of solution of chlorate. Or, after filtration, the whole acid may be neutralized by carbonate of barytes, and the chlorate of that earth being obtained in crystals, is employed to procure the acid, as directed by M. Gay Lussac.

ACID (NANCEIC); an acid called by M. Braconnot nanceic, in honour of the town of Nancy, where he lives. He discovered it in many acescent vegetable substances; in sour rice; in putrefied juice of beet-root; in sour decoction of carrots, peas, &c. He imagines that this acid is generated at the same time as vinegar in organic substances, when they become sour. It is without colour, does not crystallize, and has a very acid taste.

He concentrates the soured juice of the beet-root till it become almost solid, digests it with alcohol, and evaporates the alcoholic solution to the consistence of syrup. He dilutes this with water, and throws into it carbonate of zinc till it be saturated. He passes the liquid through a filter, and evaporates till a pellicle appear. The combination of the new acid with oxide of zinc crystallizes. After a second crystallization, he redissolves it in water, pours in an excess of water of barytes, decomposes by sulphuric acid the barytic salt formed, separates the deposit by a filter, and obtains, by evaporation, the new acid pure.

It forms with alumina a salt resembling gum, and with magnesia one unalterable in the air, in little granular crystals, soluble in 25 parts of water at 66° Fahr.; with potash and soda it forms uncrystallizable salts, deliquescent and soluble in alcohol; with lime and strontites, soluble granular salts; with barytes, an uncrystallizable nondeliquescent salt, having the aspect of gum; with white oxide of manganese, a salt which crystallizes in tetrahedral prisms, soluble in 12 parts of water at 60°; with oxide of zinc, a salt crystallizing in square prisms, terminated by summits obliquely truncated, soluble in 50 parts of water at 66°; with iron, a salt crystallizing in slender four-sided needles, of sparing solubility, and not changing in the air; with red oxide of iron, a white noncrystallizing salt; with oxide of tin, a salt crystallizing in wedge-form octahedrons; with oxide of lead, an uncrystallizible salt, not deliquescent, and resembling a gum; with black oxide of mercury, a very soluble salt, which crystallizes in needles.

ACID (NITRIC). Three parts of pure nitrate of potash, coarsely powdered, are to be put into a glass retort, with two of strong sulphuric acid. This must be cautiously added, taking care to avoid the fumes that arise. Join to the retort a tubulated receiver of large capacity, with an adopter interposed, and lute the junctures with glazier's putty. In the tubulure, fix a glass tube, terminating in another large receiver, in which is a small quantity of water; and, if you wish to collect the gaseous products, let a bent glass tube from this receiver communicate with a pneumatic trough. Apply heat to the receiver by means of a sand bath. The first product that passes into the receiver is generally red and fuming; but the appearances gradually diminish, till the acid comes over pale, and even colourless, if the materials used were clean. After this it again becomes more and more red and fuming, till the end of the operation; and the whole mingled together will be of a yellow or orange colour.

Empty the receiver, and again replace it. Then introduce by a small funnel, very cautiously, one part of boiling water in a slender stream, and continue the distillation. A small quantity of a weaker acid will thus be obtained, which can be kept apart. The first will have a specific gravity of about 1.500, if the heat have been properly regulated, and if the receiver was refrigerated by cold water or ice. Acid of that density, amounting to two-thirds of the weight of the nitre, may thus be procured. But commonly the heat is pushed too high, whence more or less of the acid is decomposed, and its proportion of water uniting to the remainder, reduces its strength. It is not profitable to use a smaller proportion of sulphuric acid, when a concentrated nitric is required. But when only a dilute acid, called in commerce *aquafortis*, is required, then less sulphuric acid will suffice, provided a portion of water be added. One hundred parts of good nitre, sixty of strong sulphuric acid, and twenty of water, form economical proportions.

As this acid still holds in solution more or less nitrous gas, it is not in fact pure; it is therefore necessary to put it into a retort, to which a receiver is added, the two vessels not being luted, and to apply a very gentle heat, changing the receiver as soon as it is filled with red vapours. The nitrous gas will thus be expelled, and the nitric acid will remain in the retort as limpid and colourless as water. It should be kept in a bottle secluded from the light, otherwise it will lose part of its oxygen.

What remains in the retort is a bisulphate of potash.

As nitric acid in a fluid state is always mixed with water, different attempts have been made to ascertain its strength, or the quantity of real acid contained in it.

Mr. Kirwan gave 68 as the quantity of real acid in 100 of the liquid acid of specific gravity 1.500: Sir H. Davy's determination was 91; Dr. Wollaston's, as inferred from the experiments of Mr. R. Philips, 75; and Mr. Dalton's corrected result from Kirwan's table was 68. In this state of discordance I performed a series of experiments, with the view of determining the constitution of liquid nitric acid, and published an account of them, with some new tables, in the fourth and sixth volumes of the Journal of Science and the Arts.

From regular prisms of nitre I procured, by slow distillation, with concentrated oil of vitriol, nitric acid; which by the tests of nitrates of silver and of barytes was found to be pure. Only the first portion that came over was employed for the experiments. It was nearly colourless, and had a specific gravity of 1.500. A redistilled and colourless nitric acid, prepared in London, was also used for experiments of verification, in estimating the quantity of dry acid in liquid acid of a known density.

The above acid of 1.500 being mixed in numbered phials, with pure water, in the different proportions of 95 + 5, 90 + 10, 80 + 20, &c. I obtained, after due agitation, and an interval of 24 hours, liquids whose specific gravities, at 60° Fahrenheit, were determined by means of an accurate balance, with a narrow-necked glass globe of known capacity. By considering the series of numbers thus obtained, I discovered the geometrical law which regulates them. The specific gravity of dilute acid, containing 10 parts in the 100 of that whose density is 1.500, is 1.054. Taking this number as the root, its successive powers will give us the successive densities, at the terms of 20, 30, 40, &c. per cent. Thus $1.054^2 = 1.111$ is the specific gravity corresponding to 20 of the strong liquid acid + 80 water; $1.054^3 = 1.171$, is that for 30 per cent. of strong acid; $1.054^4 = 1.234$, is the specific gravity at 40 per cent. The specific gravities are therefore a series of numbers in geometrical progression, corresponding to the terms of dilution, another series in arithmetical progression, exactly as I had shown in the 7th number of the Journal of Science with regard to sulphuric acid. Hence, if one term be given, the whole series may be found. On uniting the strong acid with water, a considerable condensation of volume takes place. The *maximum* condensation occurs when 58 of acid are mixed with 42 of water. Above this point the curve of condensation has a contrary flexure; and therefore a small modification must be made on the root 1.054, in order to obtain with final accuracy, in the higher part of the range, the numerical powers which represent the specific gravities. The modification is however very simple. To obtain the number for 50 per cent. the root is 1.053; and for each decade up to 70, the root must be diminished by 0.002. Thus for 60, it will become 1.051, and for 70, 1.049. Above this we shall obtain a precise correspondence with experiment, up to 1.500 sp. gravity, if for each successive decade we subtract 0.0025 from the last diminished root, before raising it to the desired power, which represents the per-centage of liquid acid.

It is established by the concurring experiments of Sir H. Davy and M. Gay Lussac, that dry nitric acid is a compound of 2½ volumes of oxygen combined with 1 of nitrogen; of which the weights are 2.5 × 1.111 = 2.777 for the proportion of oxygen, and 0.9722 for that of nitrogen; and in 100 parts, of 73⅓ of the former + 26⅔ of the latter. But nitrogen combines with several inferior proportions of oxygen, which are all multiples of its prime equivalent 1.0; and the present compound is exactly represented by making 1 prime of nitrogen = 1.75, and 5 of oxygen = 5.0: whence the acid prime is the sum of these two numbers, or 6.75. Now this result deduced from its constituents coincides perfectly with that derived from the quantity in which this acid saturates definite quantities of the salifiable bases, potash, soda, lime, &c. There can be no doubt, therefore, that the prime equivalent of the acid is 6.75; and as little that it consists of 5 parts of oxygen, and 1.75 of nitrogen. Possessed of these data, we may perhaps see some reason why the greatest condensation of volume, in diluting strong liquid acid, should take place with 58 of it, and 42 of water. Since 100 parts of acid of 1.500 contain, by my experiments, 79.7 of dry acid, therefore acid of the above dilution will contain 46 dry acid, and 54 water; or reducing the numbers to prime proportions, we have the ratio of 6.75 to 7.875, being that of one prime of real acid to 7 primes of water. But we have seen that the real acid prime is made up of 1 of nitrogen associated by chemical affinity with 5 of oxygen. Now imagine a figure, in which the central prime of nitrogen is surrounded by 5 of oxygen. To the upper and under surface of the nitrogen let a prime of water be attached, and one also to each of the primes of oxygen. We have thus the 7 primes distributed in the most compact and symmetrical manner. By this *hypothesis*, we can understand how the elements of acid and water may have such a collocation and proportion, as to give the utmost efficacy to their reciprocal attractions, whence the *maximum* condensation will result. A striking analogy will be found in the dilution of sulphuric acid.

If on 58 parts by weight of acid of 1.500, we pour cautiously 42 of water in a graduated measure, of which the whole occupies 100 divisions, and then mix them intimately, the temperature will rise from 60° to 140°, and after cooling to 60° again, the volume will be found only 92.65. No other proportion of water and acid causes the evolution of so much heat. When 90 parts of the strong acid are united with 10 of water, 100 in volume become 97; and when 10 parts of the same acid are combined with 90 of water, the resulting volume is 98. It deserves notice, that 80 of acid + 20 water, and 30 of acid + 70 water, each gives a dilute acid, whose degree of condensation is the same; namely, 100 measures become 94.8.

TABLE of Nitric Acid, by DR. URE.

Specific Gravity.	Liq. Acid in100.	Dry acid in 100.	Specific Gravity.	Liq. Acid in100.	Dry acid in 100.	Specific Gravity.	Liq Acid in100.	Dry acid in 100.	Specific Gravity.	Liq. Acid in100.	Dry aci in 100.
1.5000	100	79.700	1.4189	75	59.775	1.2947	50	39.850	1.1403	25	19.925
1.4980	99	78.903	1.4147	74	58.978	1.2887	49	39.053	1.1345	24	19.128
1.4960	98	78.106	1.4107	73	58.181	1.2826	48	38.256	1.1286	23	18.331
1.4940	97	77.309	1.4065	72	57.384	1.2765	47	37.459	1.1227	22	17.534
1.4910	96	76.512	1.4023	71	56.587	1.2705	46	36.662	1.1168	21	16.737
1.4880	95	75.715	1.3978	70	55.790	1.2644	45	35.865	1.1109	20	15.940
1.4850	94	74.918	1.3945	69	54.993	1.2583	44	35.068	1.1051	19	15.143
1.4820	93	74.121	1.3882	68	54.196	1.2523	43	34.271	1.0993	18	14.346
1.4790	92	73.324	1.3833	67	53.399	1.2462	42	33.474	1.0935	17	13.549
1.4760	91	72.527	1.3783	66	52.602	1.2402	41	32.677	1.0878	16	12.752
1.4730	90	71.730	1.3732	65	51.805	1.2341	40	31.880	1.0821	15	11.955
1.4700	89	70.933	1.3681	64	51.068	1.2277	39	31.083	1.0764	14	11.158
1.4670	88	70.136	1.3630	63	50.211	1.2212	38	30.286	1.0708	13	10.361
1.4640	87	69.339	1.3579	62	49.414	1.2148	37	29.489	1.0651	12	9.564
1.4600	86	68.542	1.3529	61	48.617	1.2084	36	28.692	1.0595	11	8.767
1.4570	85	67.745	1.3477	60	47.820	1.2019	35	27.895	1.0540	10	7.970
1.4530	84	66.948	1.3427	59	47.023	1.1958	34	27.098	1.0485	9	7.173
1.4500	83	66.155	1.3376	58	46.226	1.1895	33	26.301	1.0430	8	6.376
1.4460	82	65.354	1.3323	57	45.429	1.1833	32	25.504	1.0375	7	5.579
1.4424	81	64.557	1.3270	56	44.632	1.1770	31	24.707	1.0320	6	4.782
1.4385	80	63.760	1.3216	55	43.835	1.1709	30	23.900	1.0267	5	3.985
1.4346	79	62.963	1.3163	54	43.038	1.1648	29	23.113	1.0212	4	3.188
1.4306	78	62.166	1.3110	53	42.241	1.1587	28	22.316	1.0159	3	2.391
1.4269	77	61.369	1.3056	52	41.444	1.1526	27	21.519	1.0106	2	1.594
1.4228	76	60.572	1.3001	51	40.647	1.1465	26	20.722	1.0053	1	0.797

The column of dry acid shows the weight which any salifiable base would gain, by uniting with 100 parts of the liquid acid of the corresponding specific gravity. But it may be proper here to observe, that Sir H. Davy, in extending his views relative to the constitution of the dry muriates, to the nitrates, has suggested, that the latter when dry may be considered as consisting, not of a dry nitric acid combined *with* the salifiable oxide, but of the oxygen and nitrogen of the nitric acid with the metal itself in triple union. A view of his reasoning will be found under the article SALT. *He regards* liquid nitric acid at its utmost density as a compound of 1 prime of hydrogen, 1 of nitrogen, and 6 of oxygen.

The strongest acid that Mr. Kirwan could procure at 60° was 1.5543; but Rouelle professes to have obtained it of 1.583.

Nitric acid should be of the specific gravity of 1.5, or a little more, and colourless.

That of Mr. Kirwan seems to have consisted of one prime of real acid and one of water, when the suitable corrections are made; but no common chemical use requires it of such a strength.

The *atomical relationships* of Acid and Water were thus presented by me in a tabular form in the Journal of Science, for January, 1819, p. 248.

Liquid Acid of 1.5.	Sp. Grav.	Atoms of dry Acid.	Atoms of Water.
100	1.5000	100	152
98	1.4960	100	168
96	1.4910	100	183
94	1.4850	100	200
92	1.4790	100	216
90	1.4730	100	236
86	1.4600	100	275
84	1.4530	100	294
83½ nearly.	. . .	100	300
83	1.4500	100	305
57½	1.3340	100	700
47	1.2765	100	1000

The following table of boiling points has been given by Mr. Dalton.

Acid of sp. gr.	1.50 boils at	210°
	1.45	240
	1.42	248
	1.40	247
	1.35	242
	1.30	236
	1.20	226
	1.15	219

At 1.42 specific gravity it distils unaltered. Stronger acid than that becomes weaker, and weaker acid stronger, by boiling. When the strong acid is cooled down to — 60° it concretes, by slight agitation, into a mass of the consistence of butter.

This acid is eminently corrosive, and hence its old name of *aquafortis*. Its taste is sour and acrid. It is a deadly poison when introduced into the stomach in a concentrated state; but when greatly diluted, it may be swallowed without inconvenience. It is often contaminated, through negligence or fraud in the manufacturer, with sulphuric and muriatic acids. Nitrate of lead detects both, or nitrate of barytes may be employed to determine the quantity of sulphuric acid, and nitrate of silver that of the muriatic. The latter proceeds from the crude nitre usually containing a quantity of common salt.

When it is passed through a red-hot porcelain tube, it is resolved into oxygen and nitrogen, in the proportion above stated. It retains its oxygen with little force, so that it is decomposed by all combustible bodies. Brought into contact with hydrogen gas at a high temperature, a violent detonation ensues; so that this must not be done without great caution. It inflames essential oils, as those of turpentine and cloves, when suddenly poured on them; but, to perform this experiment with safety, the acid must be poured out of a bottle tied to the end of a long stick, otherwise the operator's face and eyes will be endangered. If it be poured on perfectly dry charcoal powder, it excites combustion, with the emission of copious fumes. By boiling it with sulphur it is decomposed, and its oxygen, uniting with the sulphur, forms sulphuric acid.

Proust has ascertained, that acid having the specific gravity 1.48, has no more action on tin than on sand, while acid somewhat stronger or weaker acts furiously on the metal. Now, acid of 1.485, by my table, consists of one prime of real acid united with two of water, constituting, it would thus appear, a peculiarly powerful combination.

Acid which takes up $\frac{418}{1000}$ of its weight of marble, freezes, according to Mr. Cavendish, at — 2°. When it can dissolve $\frac{681}{1000}$, it requires to be cooled to — 41°.6 before congelation; and when so much diluted as to take up only $\frac{278}{1000}$, it congeals at — 40°.3. The first has a specific gravity of 1.330 nearly, and consists of 1 prime of dry acid + 7 of water; the second has a specific gravity of 1.420, and contains exactly one prime of dry acid + four of water; while the third has a specific gravity of 1.215, consisting of one prime of acid + 14 of water. We perceive, that the liquid acid of 1.420, composed of 4 primes of water + one of dry acid, possesses the greatest power of resisting the influence of temperature to change its state. It requires the maximum heat to boil it, when it distils unchanged; and the maximum cold to effect its congelation.

The colour of the acid is affected by the quantity of nitric oxide it holds, and Sir H. Davy has given us the following table of proportions answering to its different hues.

Colour.	Real Acid.	Nitric Oxide.	Water.
Pale yellow,	90.5	1.2	8.3
Bright yellow,	88.94	2.96	8.10
Dark orange,	86.84	5.56	7.6
Light olive,	86.0	6.45	7.55
Dark olive,	85 4	7.1	7.5
Bright green,	84 8	7.76	7.44
Blue green,	84.6	8.	7.4

But these colours are not exact indications of the state of the acid, for an addition of water will change the colour into one lower in the scale, so that a considerable portion of water will change the dark orange to a blue-green.

Nitric acid is of considerable use in the arts. It is employed for etching on copper; as a solvent of tin to form with that metal a mordant for some of the finest dyes; in metallurgy and assaying; in various chemical processes, on account of the facility with which it parts with oxygen and dissolves metals; in medicine as a tonic, as also in form of vapour to destroy contagion. For the purposes of the arts it is commonly used in a diluted state, and contaminated with the sulphuric and muriatic acids, by the name of *aquafortis*. Two kinds are found in the shops, one called *double aquafortis*, which is about half the strength of nitric acid; the other simply *aquafortis*, which is half the strength of the double.

A compound made by mixing two parts of the nitric acid with one of muriatic, known formerly by the name of *aqua regia*, and now by that of *nitro-muriatic acid*, has the property of dissolving gold and platina. On mixing the two acids, heat is given out, an effervescence takes place, and the mixture acquires an orange colour. This is likewise made by adding gradually to an ounce of powdered muriate of ammonia four ounces of double aquafortis, and keeping the mixture in a sand heat till the salt is dissolved; taking care to avoid the fumes, as the vessel must be left open; or by distilling nitric acid with an equal weight, or rather more, of common salt.

On this subject we are indebted to Sir H. Davy for some excellent observations, published by him in the first volume of the Journal of Science. If strong *nitrous* acid, saturated with nitrous gas, be mixed with a saturated solution of muriatic acid gas, no other effect is produced than might be expected from the action of nitrous acid of the same strength on an equal quantity of water; and the mixed acid so formed has no power of action on gold or platina. Again, if muriatic acid gas, and nitrous gas, in equal volumes, be mixed together over mercury, and half a volume of oxygen be added, the immediate condensation will be no more than might be expected from the formation of nitrous acid gas. And when this is decomposed, or absorbed by the mercury, the muriatic acid gas is found unaltered, mixed with a certain portion of nitrous gas.

It appears then that *nitrous* acid, and muriatic acid gas, have no chemical action on each other. If *colourless nitric* acid and muriatic acid of commerce be mixed together, the mixture immediately becomes yellow, and gains the power of dissolving gold and platinum. If it be gently heated, pure chlorine arises from it, and the colour becomes deeper. If the heat be longer continued, chlorine still rises, but mixed with nitrous acid gas. When the process has been very long continued till the colour becomes very deep, no more chlorine can be procured, and it loses its power of acting upon platinum and gold. It is now *nitrous* and muriatic acids. It appears then from these observations, which have been very often repeated, that nitro-muriatic acid owes its peculiar properties to a mutual decomposition of the nitric and muriatic acids; and that water, chlorine, and nitrous acid gas, are the results. Though nitrous gas and chlorine have no action on each other when perfectly dry, yet if water be present there is an immediate decomposition, and nitrous acid and muriatic acid are formed. 118 parts of strong liquid nitric acid being decomposed in this case, yield 67 of chlorine. *Aqua regia* does not oxidize gold and platina. It merely causes their combination with chlorine.

A bath made of nitro-muriatic acid, diluted so much as to taste no sourer than vinegar, or of such a strength as to prick the skin a little, after being exposed to it for twenty minutes or half an hour, has been introduced by Dr. Scott of Bombay as a remedy in chronic siphylis, a variety of ulcers and diseases of the skin, chronic hepatitis, bilious dispositions, general debility, and languor. He considers every trial as quite inconclusive where a ptyalism, some affection of the gums, or some very evident constitutional effect, has not arisen from it. The internal use of the same acid has been recommended to be conjoined with that of the partial or general bath.

With the different bases the nitric acid forms nitrates.

The nitrate of barytes, when perfectly pure, is in regular octaëdral crystals, though it is sometimes obtained in small shining scales. It may be prepared by uniting barytes directly with nitric acid, or by decomposing the carbonate or sulphuret of barytes with this acid. Exposed to heat it decrepitates, and at length gives out its acid, which is decomposed; but if the heat be urged too far, the barytes is apt to vitrify with the earth of the crucible. It is soluble in 12 parts of cold, and 3 or 4 of boiling water. It is said to exist in some mineral waters. It consists of 6·75 acid + 9.75 base.

The nitrate of potash is the salt well known by the name of *nitre* or *saltpetre*. It is found ready formed in the East Indies, in Spain, in the kingdom of Naples, and elsewhere, in considerable quantities; but nitrate of lime is still more abundant. Far the greater part of the nitrate made use of is produced by a combination of circumstances which tend to compose and condense nitric acid. This acid appears to be produced in all situations, where animal matters are completely decomposed with access of air, and of proper substances with which it can readily combine. Grounds frequently trodden by cattle, and impregnated with their excrements, or the walls of inhabited places, where putrid animal vapours abound, such as slaughter-houses, drains, or the like, afford nitre by long exposure to the air. Artificial nitre beds are made by an attention to the circumstances in which this salt is produced by nature. Dry ditches are dug, and covered with sheds, open at the sides, to keep off the rain: these are filled with animal substances—such as dung, or other excrements, with the remains of vegetables, and old mortar, or other loose calcareous earth; this substance being found to be the best and most convenient receptacle for the acid to combine with. Occasional watering, and turning up from time to time, are necessary to accelerate the process, and increase the surfaces to which the air may apply; but too much moisture is hurtful. When a certain portion of nitrate is formed, the process appears to go on more quickly; but a certain quantity stops it altogether, and after this cessation the materials will go on to furnish more, if what is formed be extracted by lixiviation. After a succession of many months, more or less, according to the management of the operation, in which the action of a regular current of fresh air is of the greatest importance, nitre is found in the mass. If the beds contained much vegetable matter, a considerable portion of the nitrous salt will be common saltpetre; but if otherwise, the acid will, for the most part, be combined with the calcareous earth.

To extract the saltpetre from the mass of earthy matter, a number of large casks are prepared, with a cock at the bottom of each, and a quantity of straw within, to prevent its being stopped up. Into these the matter is put, together with wood-ashes, either strewed at top, or added during the filling. Boiling water is then poured on, and suffered to stand for some time; after which it is drawn off, and other water added in the same manner, as long as any saline matter can be thus extracted. The weak brine is heated, and passed through other tubs, until it becomes of considerable strength. It is then carried to the boiler, and contains nitre and other salts; the chief of which is common culinary salt, and sometimes muriate of magnesia. It is the property of nitre to be much more soluble in hot than cold water; but common salt is very nearly as soluble in cold as in hot water. Whenever, therefore, the evaporation is carried by boiling to a certain point, much of the common salt will fall to the bottom, for want of water to hold it in solution, though the nitre will remain suspended by virtue of the heat. The common salt thus separated is taken out with a perforated ladle, and a small quantity of the fluid is cooled, from time to time, that its concentration may be known by the nitre which crystallizes in it. When the fluid is sufficiently evaporated, it is taken out and cooled, and great part of the nitre separates in crystals; while the remaining common salt continues dissolved, because equally soluble in cold and in hot water. Subsequent evaporation of the residue will separate more nitre in the same manner. By the suggestion of Lavoisier, a much simpler plan was adopted; reducing the crude nitre to powder, and washing it twice with water.

This nitre, which is called nitre of the first boiling, contains some common salt; from which it may be purified by solution in a small quantity of water, and subsequent evaporation; for the crystals thus obtained are much less contaminated with common salt than before; because the proportion of water is so much larger, with respect to the small quantity contained by the nitre, that very little of it will crystallize. For nice purposes, the solution and crystallization of nitre are repeated four times. The crystals of nitre are usually of the form of six-sided flattened prisms, with diëdral summits. Its taste is penetrating; but the cold produced by placing the salt to dissolve in the mouth, is such as to predominate over the real taste at first. Seven parts of water dissolve two of nitre, at the temperature of sixty degrees; but boiling water dissolves its own weight. 100 parts of alcohol, at a heat of 176°, dissolve only 2.9. Its constituents are nitric acid 6.75+potash 6.

On being exposed to a gentle heat nitre fuses; and in this state being poured into moulds, so as to form little round cakes, or balls, it is called *sal prunella*, or *crystal mineral.*

This salt powerfully promotes the combustion of inflammable substances. Two or three parts mixed with one of charcoal, and set on fire, burn rapidly; azote and carbonic acid gas are given out, and a small portion of the latter is retained by the alkaline residuum, which was formerly called *clyssus of nitre*. Three parts of nitre, two of subcarbonate of potash, and one of sulphur, mixed together in a warm mortar, form the *fulminating powder;* a small quantity of which, laid on a fire shovel, and held over the fire till it begins to melt, explodes with a loud sharp noise. Mixed with sulphur and charcoal it forms *gunpowder*. See GUNPOWDER.

Three parts of nitre, one of sulphur, and one of fine saw-dust, well mixed, constitute what is called the powder of fusion. If a bit of base copper be folded up and covered with this powder in a walnut-shell, and the powder be set on fire with a lighted paper, it will detonate rapidly, and fuse the metal into a globule of sulphuret without burning the shell.

Silex, alumina, and barytes, decompose this salt in a high temperature by uniting with its base. The alumina will effect this even after it has been made into pottery.

The uses of nitre are various. Beside those already indicated, it enters into the composition of fluxes, and is extensively employed in metallurgy; it serves to promote the combustion of sulphur in fabricating its acid; it is used in the art of dyeing; it is added to common salt for preserving meat, to which it gives a red hue; it is an ingredient in some frigorific mixtures; and it is prescribed in medicine, as cooling, febrifuge, and diuretic; and some have recommended it mixed with vinegar as a very powerful remedy for the sea scurvy.

Nitrate of soda, formerly called *cubic* or *quadrangular nitre*, approaches in its properties to the nitrate of potash; but differs from it in being somewhat more soluble in cold water, though less in hot, which takes up little more than its own weight; in being inclined to attract moisture from the atmosphere; and in crystallizing in rhombs, or rhomboidal prisms. It may be prepared by saturating soda with the nitric acid; by precipitating nitric solutions of the metals, or of the earths, except barytes, by soda; by lixiviating and crystallizing the residuum of common salt distilled with three-fourths its weight of nitric acid; or by saturating the mother waters of nitre with soda instead of potash.

This salt has been considered as useless; but professor Proust says, that five parts of it, with one of charcoal and one of sulphur, will burn three times as long as common powder, so as to form an economical composition for fire-works. It consists of 6.75 acid + 4. soda.

Nitrate of strontian may be obtained in the same manner as that of barytes, with which it agrees in the shape of its crystals, and most of its properties. It is much more soluble, however, requiring but four or five parts of water according to Vauquelin, and only an equal weight according to Mr. Henry. Boiling water dissolves nearly twice as much as cold. Applied to the wick of a candle, or added to burning alcohol, it gives a deep red colour to the flame. On this account it is useful in the art of pyrotechny. It consists of 6.75 acid + 6.5 strontites.

Nitrate of lime, the *calcareous nitre* of older writers, abounds in the mortar of old buildings, particularly those that have been much exposed to animal effluvia, or processes in which azote is set free. Hence, it abounds in nitre beds, as was observed when treating of the nitrate of potash. It may also be prepared artificially, by pouring dilute nitric acid on carbonate of lime. If the solution be boiled down to a syrupy consistence, and exposed in a cool place, it crystallizes in long prisms, resembling bundles of needles diverging from a centre. These are soluble, according to Henry, in an equal weight of boiling water, and twice their weight of cold; soon deliquesce on exposure to the air, and are decomposed at a red heat. Fourcroy says, that cold water dissolves four times its weight, and that its own water of crystallization is sufficient to dissolve it at a boiling heat. It is likewise soluble in less than its weight of alcohol. By evaporating the aqueous solution to dryness, continuing the heat till the nitrate fuses, keeping it in this state five or ten minutes, and then pouring it into an iron pot previously heated, we obtain *Baldwin's phosphorus*. This, which is perhaps more properly *nitrate of lime*, being broken to pieces, and kept in a phial closely stopped, will emit a beautiful white light in the dark, after having been exposed some time to the rays of the sun. At present no use is made of this salt, except for drying some of the gases by attracting their moisture; but it might be employed instead of the nitrate of potash for manufacturing aquafortis.

The nitrate of ammonia possesses the property of exploding and being totally decomposed, at the temperature of 600°; whence it acquired the name of *nitrum flammans*. The readiest mode of preparing it is by adding carbonate of ammonia to dilute nitric acid till saturation takes place. If this solution be evaporated in a heat between 70° and 100°, and the evaporation not carried too far, it crystallizes in hexaëdral prisms terminating in very acute pyramids: if the heat rise to 212°, it will afford, on cooling, long fibrous silky crystals: if the evaporation be carried so far as for the salt to concrete immediately on a glass rod by cooling, it will form a compact mass. According to Sir H. Davy, these differ but little from each other, except in the water they contain, their component parts being as follows:

	contains of acid	ammonia	water
Prismatic	69.5	18.4	12.1
Fibrous	72.5	19.3	8.2
Compact	74.5	19.8	5.7

All these are completely deliquescent, but they differ a little in solubility. Alcohol at 176° dissolves nearly 90.9 of its own weight.

When dried as much as possible without decomposition, it consists of 6.75 acid + 2.125 ammonia + 1.125 water.

The chief use of this salt is for affording nitrous oxide on being decomposed by heat. See NITROGEN (OXIDE of).

Nitrate of magnesia, *magnesian nitre*, crystallizes in four-sided rhomboidal prisms, with oblique or truncated summits, and sometimes in bundles of small needles. Its taste is bitter, and very similar to that of nitrate of lime, but less pungent. It is fusible, and decomposable by heat, giving out first a little oxygen gas, then nitrous oxide, and lastly nitric acid. It deliquesces slowly. It is soluble in an equal weight of cold water, and in but little more of hot, so that it is scarcely crystallizable but by spontaneous evaporation.

The two preceding species are capable of combining into a triple salt, an ammoniaco-magnesian nitrate, either by uniting the two in solution, or by a partial decomposition of either by means of the base of the other. This is slightly inflammable when suddenly heated; and by a lower heat is decomposed, giving out oxygen, azote, more water than it contained, nitrous oxide, and nitric acid. The residuum is pure magnesia. It is disposed to attract moisture from the air, but is much less deliquescent than either of the salts that compose it, and requires eleven parts of water at 60° to dissolve it. Boiling water takes up more, so that it will crystallize by cooling. It consists of 78 parts of nitrate of magnesia, and 22 of nitrate of ammonia.

From the activity of the nitric acid as a solvent of earths in analyzation, the nitrate of glucine is better known than any other of the salts of this new earth. Its form is either pulverulent, or a tenacious or ductile mass. Its taste is at first saccharine, and afterwards astringent. It grows soft by exposure to heat, soon melts, its acid is decomposed into oxygen and azote, and its base alone is left behind. It is very soluble and very deliquescent.

Nitrate, or rather supernitrate, of alumina crystallizes, though with difficulty, in thin, soft, pliable flakes. It is of an austere and acid taste, and reddens blue vegetable colours. It may be formed by dissolving in diluted nitric acid, with the assistance of heat, fresh precipitated alumina, well washed but not dried. It is deliquescent, and soluble in a very small portion of water. Alcohol dissolves its own weight. It is easily decomposed by heat.

Nitrate of zircone was first discovered by Klaproth, and has since been examined by Guyton-Morveau and Vauquelin. Its crystals are small, capillary, silky needles. Its taste is astringent. It is easily decomposed by fire, very soluble in water, and deliquescent. It may be prepared by dissolving zircone in strong nitric acid; but, like the preceding species, the acid is always in excess.

Nitrate of yttria may be prepared in a similar manner. Its taste is sweetish and astringent. It is scarcely to be obtained in crystals; and if it be evaporated by too strong a heat, the salt becomes soft like honey, and on cooling concretes into a stony mass. See SALT.

ACID (NITROUS). This acid is obtained by exposing nitrate of lead to heat in a glass retort. Pure *nitrous* acid comes over in the form of an orange-coloured liquid. It is so volatile as to boil at the temperature of 82°. Its specific gravity is 1.450. When mixed with water it is decomposed, and nitrous gas is disengaged, occasioning effervescence. It is composed of one volume of oxygen united with two of nitrous gas. It therefore consists ultimately, by weight, of 1.75 nitrogen + 4 oxygen; by measure, of 2 oxygen + 1 nitrogen. The various coloured acids of nitre are not *nitrous* acids, but nitric acid impregnated with nitrous gas, the deutoxide of nitrogen or azote. (See the preceding table of Sir H. Davy, concerning the coloured acid).

ACID (HYPONITROUS). It appears, from the experiments of M. Gay Lussac, that there exists a third acid, formed of 100 azote and 150 oxygen. When into a test tube filled with mercury, we pass up from 500 to 600 volumes of deutoxide of azote, a little alkaline water, and 100 parts of oxygen gas, we obtain an absorption of 500, proceeding from the condensation of the 100 parts of oxygen with 400 of deutoxide of azote. Now these 400 parts are composed of 200 azote and 200 oxygen; consequently the new acid is composed of azote and oxygen, in the ratio of 100 to 150, as we have said above. It is the same acid, according to M. Gay Lussac, which is produced on leaving for a long time a strong solution of potash in contact with deutoxide of azote. At the end of three months he found that 100 parts of deutoxide of azote were reduced to 25 of protoxide of azote, and that crystals of *hyponitrite* (*pernitrite*) were formed.

Hyponitrous acid (called *pernitrous* by the French chemists), cannot be insulated. As soon as we lay hold, by an acid, of the potash with which it is associated, it is transformed into deutoxide of azote, which is disengaged, and into nitrous or nitric acid which remains in solution.

ACID (NITRO-LEUCIC). *Leucine* is capable of uniting to nitric acid, and forming a compound, which M. Braconnot has called the nitro-leucic acid. When we dissolve leucine in nitric acid, and evaporate the solution to a certain point, it passes into a crystalline mass, without any disengagement of nitrous vapour, or of any gaseous matter: If we press this mass between blotting paper, and redissolve it in water, we shall obtain from this, by concentration, fine, divergent, and nearly colourless needles. These constitute the new acid. It unites to the bases forming salts, which fuse on red-hot coals. The nitro-leucates of lime and magnesia are unalterable in the air.

ACID (NITRO-SACCHARIC). When we heat the *sugar of gelatine* with nitric acid, it dissolves without any apparent disengagement of gas, and if we evaporate this solution to a proper degree, it forms, on cooling, a crystalline mass. On pressing this mass between the folds of blotting paper, and recrystallizing them, we obtain beautiful prisms, colourless, transparent, and slightly striated. These crystals are very different from those which serve to produce them; constitute, according to M. Braconnot, a true acid, which results from the combination of the nitric acid itself, with the sweet matter of which the first crystals are formed. M. Thenard conceives it is the *nitrous* acid which is present.

Nitro-saccharic acid has a taste similar to that of the tartaric; only it is a little sweetish. Exposed to the fire in a capsule, it froths much, and is decomposed with the diffusion of a pungent smell. Thrown on burning coals it acts like saltpetre. It produces no change in saline solutions. Finally, it combines with the bases, and gives birth to salts which possess peculiar properties. For example, the salt which it forms with lime is not deliquescent, and is very little soluble in strong alcohol. That which it produces with the oxide of lead detonates to a certain degree by the action of heat. *Ann. de Chimie et de Phys.* xiii. 113.

ACID (NITRIC, OXYGENIZED). In our general remarks on acidity, we have described M. Thenard's newly discovered method of oxygenizing the liquid acids. The first that he examined was the combination of nitric acid and oxygen. When the peroxide of barium, prepared by saturating barytes with oxygen, is moistened, it falls to powder, without much increase of temperature. If in this state it be mixed with seven or eight times its weight of water, and dilute nitric acid be gradually poured upon it, it dissolves gradually by agitation, without the evolution of any gas. The solution is neutral, or has no action on turnsole or turmeric. When we add to this solution the requisite quantity of sulphuric acid, a copious precipitate of sulphate of barytes falls, and the filtered liquor is merely water, holding in solution oxygenized nitric acid. This acid is liquid and colourless: it strongly reddens turnsole, and resembles in all its properties nitric acid.

When heated it immediately begins to discharge oxygen; but its decomposition is never complete, unless it be kept boiling for some time. The only method which M. Thenard found successful for concentrating it, was to place it in a capsule, under the receiver of an air-pump, along with another capsule full of lime, and to exhaust the receiver. By this means he obtained an acid sufficiently concentrated to give out 11 times its bulk of oxygen gas.

This acid combines very well with barytes, potash, soda, ammonia, and neutralizes them. When crystallization commences in the liquid, by even a spontaneous evaporation, these salts are instantly decomposed. The exhausted receiver also decomposes them. The oxygenized nitrates, when changed into common nitrates, do not change the state of their neutralization. Strong solution of potash poured into their solutions decomposes them.

Oxygenized nitric acid does not act on gold; but it dissolves all the metals which the common acid acts on, and when it is not too concentrated, it dissolves them without effervescence. Deutoxide or peroxide of barium contains just double the proportion of oxygen that its protoxide does. But M. Thenard says, that the barytes obtained from the nitrate by ignition contains always a little of the peroxide. When oxygenized nitric acid is poured upon oxide of silver, a strong effervescence takes place, owing to the disengagement of oxygen. One portion of the oxide of silver is dissolved, the other is reduced at first, and then dissolves likewise, provided the quantity of acid be sufficient. The solution being completed, if we add potash to it, by little and little, a new effervescence takes place, and a dark violet precipitate falls; at least this is always the colour of the first deposit. It is insoluble in ammonia, and, according to all appearance, is a protoxide of silver.

As soon as we plunge a tube containing oxide of silver into a solution of oxygenized nitrate of potash, a violent effervescence takes place, the oxide is reduced, the silver precipitates, the whole oxygen of the oxygenized nitrate is disengaged at the same time with that of the oxide; and the solution, which contains merely common nitrate of potash, remains neutral, if it was so at first. But the most unaccountable phenomenon is the following: If silver, in a state of extreme division (fine filings), be put into the oxygenized nitrate, or oxygenized muriate of potash, the whole oxygen is immediately disengaged. The silver itself is not attacked, and the salt remains neutral as before. Iron, zinc, copper, bismuth, lead, and platinum, likewise possess this property of separating the oxygen of the oxygenized nitrate. Iron and zinc are oxidized, and at the same time occasion the evolution of oxygen. The other metals are not sensibly oxidized. They were all employed in the state of filings. Gold scarcely acts. The peroxides of manganese and of lead decompose these oxynitrates. A very small quantity of these oxides, in powder, is sufficient to drive off the whole oxygen from the saline solution. The effervescence is lively. The peroxide of manganese undergoes no alteration.

Though nitric acid itself has no action on the peroxides of lead and manganese, the oxygenized acid dissolves both of them with the greatest facility. The solution is accompanied by a great disengagement of oxygen gas. The effect of silver, he thinks, may probably be ascribed to voltaic electricity.

The remarks appended to our account of M. Thenard's oxygenized muriatic acid are equally applicable to the nitric; but the phenomena are too curious to be omitted in a work of the present kind.

ACID (OLEIC). When potash and hog's lard are saponified, the margarate of the alkali separates in the form of a pearly-looking solid, while the fluid fat remains in solution, combined with the potash. When the alkali is separated by tartaric acid, the oily principle of fat is obtained, which M. Chevreul purifies by saponifying it again and again, recovering it two or three times; by which means the whole of the margarine is separated. As this oil has the property of saturating bases and forming neutral compounds, he has called it oleic acid. In his sixth memoir, he gives the following table of results:—

100 Oleic acid of human fat

Saturate Barytes	Strontian	Lead
26.00	19.41	82.48
100 Oleic acid of sheep fat		
26.77	19.38	81.81
100 Oleic acid of ox fat		
28.93	19.41	81.81
100 Oleic acid of goose fat		
26.77	19.38	81.34
100 Oleic acid of hog fat		
27.00	29.38	81.80

Oleic acid is an oily fluid without taste and smell. Its specific gravity is 0.914. It is generally soluble in its own weight of boiling alcohol, of the specific gravity of 0.7952; but some of the varieties are still more soluble. 100 of the oleic acid saturate 16.58 of potash, 10.11 of soda, 7.52 of magnesia, 14.83 of zinc, and 13.93 peroxide of copper. M. Chevreul's experiments have finally induced him to adopt the quantities of 100 acid to 27 barytes, as the most correct; whence calling barytes 9.75, we have the equivalent prime of oleic acid = 36.0.

ACID (OXALIC). This acid may be obtained from sugar in the following way: To six ounces of nitric acid in a stoppered retort, add, by degrees, one ounce of lump sugar coarsely powdered. A gentle heat may be applied during the solution, and nitric oxide will be evolved in abundance. When the whole of the sugar is dissolved, distil off a part of the acid, till what remains in the retort has a syrupy consistence, and this will form regular crystals, amounting to 58 parts from 100 of sugar. These crystals must be dissolved in water, recrystallized, and dried on blotting paper.

A variety of other substances afford the oxalic acid when treated by distillation with the nitric. Bergman procured it from honey, gum-arabic, alcohol, and the calculous concretions in the kidneys and bladders of animals. Scheele and Hermbstadt from sugar of milk. Scheele from a sweet matter contained in fat oils, and also from the uncrystallizable part of the juice of lemons. Hermbstadt from the acid of cherries, and the acid of tartar. Goettling from beech wood. Kohl from the residuum in the distillation of ardent spirits. Westrumb not only from the crystallized acids of currants, cherries, citrons, raspberries, but also from the saccharine matters of these fruits, and from the uncrystallizable parts of the acid juices. Hoffmann from the juice of the barberry; and Berthollet from silk, hair, tendons, wool; also from other animal substances, especially from the coagulum of blood, whites of eggs, and likewise from the amylaceous and glutinous parts of flour. M. Berthollet observes, that the quantity of the oxalic acid obtained by treating wool with nitric acid was very considerable, being above half the weight of the wool employed. He mentions a difference which he observed between animal and vegetable substances thus treated with nitric acid, namely, that the former yielded, beside ammonia, a large quantity of an oil which the nitric acid could not decompose; whereas the oily parts of vegetables were totally destroyed by the action of this acid: and he remarks, that in this instance the glutinous part of flour resembled animal substances, whereas the amylaceous part of the flour retained its vegetable properties. He further remarks, that the quantity of oxalic acid furnished by vegetable matters thus treated is proportionable to their nutritive quality, and particularly that, from cotton, he could not obtain any sensible quantity. Deyeux, having cut with scissars the hairs of the chick pea, found they gave out an acid liquor, which, on examination, proved to be an aqueous solution of pure oxalic acid. Proust and other chemists had before observed, that the shoes of persons walking through a field of chick peas were corroded.

Braconnot has lately shown, that the crustaceous lichens, such as *pertusaria communis*, *urceolaria scruposa*, *isidium corallinum*, *patellaria tartarea*, *ventosa rubra*, *hematomma*, *bæomices ericetorum*, *squamaria lentigera*, *placodium radiosum*, *ochroleucum*, *psora candida*, contain nearly one half their weight of oxalate of lime, a substance which is to these plants what carbonate of lime is to corallines, and phosphate of lime to animal bones. Humboldt says, these are the lichens by which the earth void of vegetation in the north of Peru begins to be covered; by their means vegetation seems to commence on the barren surface of rocks. By the successive action of solution of carbonate of soda, aided by a boiling heat, the oxalate of lime in these plants is converted into a carbonate, while oxalate of soda remains dissolved.

Oxalic acid crystallizes in quadrilateral prisms, the sides of which are alternately broad and narrow, and summits diëdral; or, if crystallized rapidly, in small irregular needles. They are efflorescent in dry air, but attract a little humidity if it be damp; are soluble in one part of hot and two of cold water; and are decomposable by a red heat, leaving a small quantity of coaly residuum.—100 parts of alcohol take up nearly 56 at a boiling heat, but not above 40 cold. Their acidity is so great, that when dissolved in 3600 times their weight of water, the solution reddens litmus paper, and is perceptibly acid to the taste.

The oxalic acid is a good test for detecting lime, which it separates from all the other acids, unless they are present in excess. It has likewise a greater affinity for lime than for any other of the bases, and forms with it a pulverulent insoluble salt, not readily decomposable except by fire, and turning syrup of violets green.

From the oxalate of lead, Berzelius infers its prime equivalent to be 4.552, and by igneous decomposition he finds it resolved into 66.534 oxygen, 33.222 carbon, and 0.244 hydrogen. Since Berzelius published his analysis, oxalic acid has been made the subject of some ingenious remarks by Dobereiner, in the 16th vol. of Schweigger's Journal. We see that the carbon and oxygen are to each other in the simple ratio of 1 to 2; or referred to their prime equivalent, as 2 of carbon = 1.5, to 3 of oxygen = 3.0. This proportion is what would result from a prime of carbonic acid $= C + 2$. O, combined with one of carbonic oxide $= C + O$. C being carbon, and O oxygen. The sum of the above weights gives 4.5 for the prime equivalent of oxalic acid, disregarding hydrogen, which constitutes but 1-37th of the whole, and may be referred to the imperfect desiccation of the oxalate of lead subjected to analysis.

I have found in my experiments (Phil. Trans. 1822), that dry oxalate of lead ignited in contact with calomel in a glass tube, yields no trace of muriatic acid, a certain proof that no hydrogen exists in dry oxalic acid. I found the prime equivalent of oxalic acid, in crystals, to be 7.875, containing 3 atoms of water associated with the 2 atoms of carbon and 3 of oxygen, which alone enter into the above combination with oxide of lead, and which weigh 4.5.

Oxalic acid acts as a violent poison when swallowed in the quantity of 2 or 3 drachms; and several fatal accidents have lately occurred in London, in consequence of its being improperly sold instead of Epsom salts. Its vulgar name of salts, under which the acid is bought for the purpose of whitening boot-tops, occasions these lamentable mistakes. But the powerfully acid taste of the latter substance, joined to its prismatic or needle-formed crystallization, are sufficient to distinguish it from every thing else. The immediate rejection from the stomach of this acid by an emetic, aided by copious draughts of warm water containing bicarbonate of potash, or soda, chalk, or carbonate of magnesia, are the proper remedies.

With barytes it forms an insoluble salt; but this salt will dissolve in water acidulated with oxalic acid, and afford angular crystals. If, however, we attempt to dissolve these crystals in boiling water, the excess of acid will unite with the water, and leave the oxalate, which will be precipitated.

The oxalate of strontian too is a nearly insoluble compound.

Oxalate of magnesia too is insoluble, unless the acid be in excess.

The oxalate of potash exists in two states, that of a neutral salt, and that of an acidule. The latter is generally obtained from the juice of the leaves of the *oxalis acetocella*, wood sorrel, or *rumex acetosa*, common sorrel. The expressed juice, being diluted with water, should be set by for a few days, till the feculent parts have subsided, and the supernatant fluid is become clear; or it may be clarified, when expressed, with the whites of eggs. It is then to be strained off, evaporated to a pellicle, and set in a cool place to crystallize. The first product of crystals being taken out, the liquor may be further evaporated, and crystallized; and the same process repeated till no more can be obtained. In this way, Schlereth informs us, about nine drachms of crystals may be obtained from two pounds of juice, which are generally afforded by ten pounds of wood sorrel. Savary however says, that ten parts of wood sorrel in full vegetation yield five parts of juice, which give little more than a two-hundredth of tolerably pure salt. He boiled down the juice, however, in the first instance, without clarifying it; and was obliged repeatedly to dissolve and recrystallize the salt to obtain it white.

This salt is in small, white, needly, or lamellar crystals, not alterable in the air. It unites with barytes, magnesia, soda, ammonia, and most of the metallic oxides, into triple salts. Yet its solution precipitates the nitric solutions of mercury and silver in the state of insoluble oxalates of these metals, the nitric acid in this case combining with the potash. It attacks iron, lead, tin, zinc, and antimony.

This salt, besides its use in taking out ink spots, and as a test of lime, forms with sugar and water a pleasant cooling beverage; and according to Berthollet, it possesses considerable powers as an antiseptic.

The neutral oxalate of potash is very soluble, and assumes a gelatinous form, but may be brought to crystallize in hexaëdral prisms with diëdral summits, by adding more potash to the liquor than is sufficient to saturate the acid. See SALTS, TABLE OF.

Oxalate of soda likewise exists in two different states, those of an acidulous and a neutral salt, which in their properties are analogous to those of potash.

If oxalic acid be saturated with ammonia, we obtain a neutral oxalate, which on evaporation yields very fine crystals in tetraëdral prisms with diëdral summits, one of the planes of which cuts off three sides of the prism. This salt is decomposable by fire, which raises from it carbonate of ammonia, and leaves only some slight traces of a coaly residuum. Lime, barytes, and strontian unite with its acid, and the ammonia flies off in the form of gas. Its constituents are acid 4.5, ammonia 2.125, water 2.25 = 8.875.

The oxalic acid readily dissolves alumina, and the solution gives on evaporation a yellowish transparent mass, sweet and a little astringent to the taste, deliquescent, and reddening tincture of litmus, but not syrup of violets. This salt swells up in the fire, loses its acid, and leaves the alumina a little coloured.

The composition of the different oxalates may be ascertained by considering the neutral salts as consisting of one prime of acid = 4.5 to one of base, and the binoxylate of potash of 2 of acid to one of base, as was first proved by Dr. Wollaston. But this eminent philosopher has further shown, that oxalic acid is capable of combining in four proportions with the oxides, whence result neutral oxalates, suboxalates, acidulous oxalates, and acid oxalates. The neutral contain twice as much acid as the suboxalates; one-half of the quantity of acid in the acidulous oxalates; and one-quarter of that in the acid oxalates. See Salt.

ACID (PECTIC). The name given by Braconnot to an acid which he conceives to be universally diffused through vegetables, and analogous to, if not identical with jelly. 85 of this acid seem to neutralize 15 of potash, and afford a compound like gum-arabic.—*Annales de Chim. et Phys.* xxviii. 172.

ACID (PHOCENIC); The odorous principle of the soap of the dolphin oils, according to M. Chevreul. The sp. gr. of phocenic acid is 0.932. It is colourless, and takes 100 parts of water to dissolve 5.5 of it. It is soluble in alcohol in every proportion. Its constituents are in volume, 3 of oxygen, 10 of carbon, and 14 of hydrogen. 100 of phocenic acid neutralize 82.77 of barytes, forming a salt, soluble, in its own weight of water at 68° F. The disagreeable smell of leather dressed with fish oil, is ascribed by M. Chevreul to the decomposition of the phocenic acid contained in this oil.—*Annales de Chim. et de Phys.* xxiii. 16.

ACID (PHOSPHATIC). This acid is obtained by the slow combustion of cylinders of phosphorus in the air. For which purpose it is necessary that the air be renewed to support the combustion; that it be humid, otherwise the dry coat of phosphatic acid would screen the phosphorus from farther action of the oxygen; and that the different cylinders of phosphorus be insulated, to prevent the heat from becoming too high, which would melt or inflame them, so as to produce phosphoric acid. The acid, as it is formed, must be collected in a vessel, so as to lose as little of it as possible. All these conditions may be thus fulfilled: We take a parcel of glass tubes, which are drawn out to a point at one end; we introduce into each a cylinder of phosphorus a little shorter than the tube; we dispose of these tubes along-side of one another, to the amount of 30 or 40, in a glass funnel, the beak of which passes into a bottle placed on a plate, covered with water. We then cover the bottle and its funnel with a large bell-glass, having a small hole in its top, and another in its side.

A film of phosphorus first evaporates, then combines with the oxygen and the water of the air, giving birth to phosphatic acid, which collects in small drops at the end of the glass tubes, and falls through the funnel into the bottle. A little phosphatic acid is also found on the sides of the bell-glass, and in the water of the plate. The process is a very slow one.

The phosphatic acid thus collected is very dilute. We reduce it to a viscid consistence, by heating it gently; and better still, by putting it, at the ordinary temperature, into a capsule over another capsule full of concentrated sulphuric acid, under the receiver of an air-pump, from which we exhaust the air.

The acid thus formed is a viscid liquid, without colour, having a faint smell of phosphorus, a strong taste, reddening strongly the tincture of litmus, and denser than water in a proportion not well determined. Every thing leads to the belief that this acid would be solid, could we deprive it of water. When it is heated in a retort, phosphuretted hydrogen gas is evolved, and phosphoric acid remains. The oxygen and hydrogen of the water concur to this transformation. Phosphatic acid has no action, either on oxygen gas, or on the atmospheric air at ordinary temperatures. In combining with water, a slight degree of heat is occasioned.

From the experiments of M. Thenard, this acid seems to consist (exclusive of water) of 100 phosphorus united to about 110 oxygen, which is nearly the proportion of 3 primes phosphorus = (3 × 1.5) 4.5 + 6 oxygen = 5.

But 2 prim. phosphorus + 4 ox. = 4 phosphoric acid.
And 1 + 1 = 1 phosphorous acid.

Hence the phosphatic acid would seem to result from the union of 2 primes of phosphoric acid with 1 of phosphorous acid. Now, M. Dulong has shown, that the phosphatic acid in its action on the salifiable bases is transformed into phosphorous and phosphoric acids, whence proceed phosphites and phosphates.

ACID (PHOSPHORIC). Bones of beef, mutton, or veal, being calcined to whiteness in an open fire, lose almost half of their weight. These must be pounded, and sifted; or the trouble may be spared by buying the powder that is sold to make cupels for the assayers, and is, in fact, the powder of burned bones ready sifted. To three pounds of the powder there may be added about two pounds of concentrated sulphuric acid. Four or five pounds of water must be also added to assist the action of the acid. The whole may be then left on a gentle sand heat for two or three days, taking care to supply the loss of water which happens by evaporation. A large quantity of water must then be added, the whole strained through a sieve, and the residual matter, which is sulphate of lime, must be edulcorated by repeated affusions of hot water, till it passes tasteless. The waters contain phosphoric acid with a little lime; and by evaporation, first in glazed earthen, and then in glass vessels, or rather in vessels of platina or silver, for the hot acid acts upon glass, afford the impure acid in a concentrated state, which, by the force of a strong heat in a crucible, may be made to acquire the form of a transparent consistent glass, though indeed, it is usually of a milky opaque appearance.

For making phosphorus, it is not necessary to evaporate the water further than to bring it to the consistence of syrup; and the small portion of lime it contains is not an impediment worth the trouble of removing, as it affects the produce very little. But when the acid is required in a purer state, it is proper to add a quantity of carbonate of ammonia, which, by double elective attraction, precipitates the lime that was held in solution by the phosphoric acid. The fluid being then evaporated, affords a crystallized ammoniacal salt, which may be melted in a silver vessel, as the acid acts upon glass or earthen vessels. The ammonia is driven off by the heat, and the acid acquires the form of a compact glass as transparent as rock-crystal, acid to the taste, soluble in water, and deliquescent in the air.

This acid is commonly pure, but nevertheless may contain a small quantity of soda, originally existing in the bones, and not capable of being taken away by this process, ingenious as it is. The only unequivocal method of obtaining a pure acid appears to consist in first converting it into phosphorus by distillation of the materials with charcoal, and then converting this again into acid by rapid combustion, at a high temperature, either in oxygen or atmospheric air, or some other equivalent process.

Phosphorus may also be converted into the acid state by treating it with nitric acid. In this operation, a tubulated retort with a ground stopper, must be half-filled with nitric acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tube, will be dissolved with effervescence, produced by the escape of a large quantity of nitric oxide. The addition of phosphorus must be continued until the last piece remains undissolved. The fire being then raised to drive over the remainder of the nitric acid, the phosphoric acid will be found in the retort, partly in the concrete and partly in the liquid form.

When phosphorus is burned by a strong heat, sufficient to cause it to flame rapidly, it is almost perfectly converted into dry acid, some of which is thrown up by the force of the combustion, and the rest remains upon the supporter.

This substance has also been acidified by the direct application of oxygen gas passed through hot water, in which the phosphorus was liquefied or fused.

The general characters of phosphoric acid are: 1. It is soluble in water in all proportions, producing a specific gravity, which increases as the quantity of acid is greater, but does not exceed 2.687, which is that of the glacial acid. 2. It produces heat when mixed with water, though not very considerable. 3. It has no smell when pure, and its taste is sour, but not corrosive. 4. When perfectly dry, it sublimes in close vessels; but loses this property by the addition of water; in which circumstance it greatly differs from the boracic acid, which is fixed when dry, but rises by the help of water. 5. When considerably diluted with water, and evaporated, the aqueous vapour carries up a small portion of the acid. 6. With charcoal or inflammable matter, in a strong heat, it loses its oxygen, and becomes converted into phosphorus.

Phosphoric acid is difficult of crystallizing.

Though the phosphoric acid is scarcely corrosive, yet, when concentrated, it acts upon oils, which it discolours and at length blackens, producing heat, and a strong smell like that of ether and oil of turpentine; but does not form a true acid soap. It has most effect on essential oils, less on drying oils, and least of all on fat oils.

From the syntheses of the phosphates of soda, barytes, and lead, Berzelius deduces the prime equivalent of phosphoric acid to be 4.5. But the experiments of Berzelius on the synthesis of the acid itself, show it to be a compound of about 100 phosphorus + 133 oxygen. Lavoisier's synthesis gave 2 oxygen + 1.33 phosphorus. So did that of Sir H. Davy by rapid combustion in oxygen gas, as published in the Phil. Trans. for 1812. M. Dulong, in an elaborate paper published in the third volume of the Memoires D'Arcueil, gives as the result of diversified experiments, nearly the proportions of 100 phosphorus to 123 oxygen; or of 5 oxygen + 4 phosphorus = 9 for the acid equivalent.

Sir H. Davy, with his well known sagacity, invented a new method of research, to elude the former sources of error. He burned the vapour of phosphorus as it issues from a small tube, contained in a retort filled with oxygen gas. By adopting this process, he determined the composition of phosphoric acid to be 100 phosphorus + 134.5 oxygen; whence its equivalent comes out 3.500. Phosphorous acid he then shows to consist of 1 oxygen + 1.500 phosphorus = 2.500.

M. Dumas in an elaborate memoir on Phosphuretted Hydrogen (*Ann. de Chim. et de Phys.* xxxi.) endeavours to show that phosphoric acid consists of 1 atom of phosphorus, 4.0 + 5 atoms of oxygen, 5 = 9; while phosphorous acid consists of 1 atom of phosphorus 4 + 3 atoms of oxygen, 3 = 7. See PHOSPHURETTED HYDROGEN, and General Table of GASES.

By the above atomic weights 1.5 phosphorus combines with 1.125 oxygen (instead of 1) to constitute phosphorous acid; and with 1.875 oxygen to constitute phosphoric acid. If phosphoric acid be made 9, then in the phosphates of soda, barytes, and lead, we must admit 2 atoms of base; thus giving them the characters of subsalts, which that of soda manifestly possesses.

ACID (PHOSPHOROUS) was discovered in 1812 by Sir H. Davy. When phosphorus and corrosive sublimate act on each other at an elevated temperature, a liquid called protochloride of phosphorus is formed. Water added to this, resolves it into muriatic and phosphorous acids. A moderate heat suffices to expel the former, and the latter remains, associated with water. It has a very sour taste, reddens vegetable blues, and neutralizes bases. When heated strongly in open vessels, it inflames. Phosphuretted hydrogen flies off, and phosphoric acid remains. Ten parts of it heated in close vessels give off one-half of a phosphuretted hydrogen, and leave 8½ of phosphoric acid. Hence the liquid acid consists of 80.7 acid + 19.3 water. Its prime equivalent is either 2.5, or 7. See PHOS. HYDROGEN.

ACID (HYPOPHOSPHOROUS), lately discovered by M. Dulong. Pour water on the phosphuret of barytes, and wait till all the phosphuretted hydrogen be disengaged. Add cautiously to the filtered liquid dilute sulphuric acid, till the barytes be all precipitated in the state of sulphate. The supernatant liquid is hypophosphorous acid, which should be passed through a filter. This liquid may be concentrated by evaporation, till it become viscid. It has a very sour taste, reddens vegetable blues, and does not crystallize. Dulong assigns 100 phosphorus to 37.44 oxygen, which gives the proportion of 1 atom phosphorus, 4.0 + 1½ oxygen 1.5 = 5.5 for the acid prime equivalent. The hypophosphites have the remarkable property of being all soluble in water; while many of the phosphates and phosphites are insoluble.

M. Thenard succeeded in oxygenizing phosphoric acid by the method described under nitric and muriatic acids.

With regard to the phosphates and phosphites, we have many discrepancies in our latest publications. Sir H. Davy says, in his last memoir on some of the combinations of phosphorus, that "new researches are required to explain the anomalies presented by the phosphates."

Phosphoric acid, united with barytes, produces an insoluble salt, in the form of a heavy white powder, fusible at a high temperature into a grey enamel. The best mode of preparing it is by adding an alkaline phosphate to the nitrate or muriate of barytes.

By mixing phosphate of ammonia with nitrate of barytes, Berzelius found that 68.2 parts of barytes and 31.8 of phosphorus composed 100 of the phosphate. Hence it is a subphosphate, and consists of

Phosphoric acid	1 atom	=	9.0	68.42
Barytes	2	=	19.5	31.58
				100.0

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He made a phosphate by dissolving the above in dilute phosphoric acid, and evaporating, when crystals were obtained composed, in 100 parts, of acid, 42.54; barytes, 46.46; water, 11. But by theory we have,

Acid	2 atoms	18	42.857	100.000
Base	2	19.5	46.430	
Water	4	4.5	10.713	

By pouring a solution of the preceding salt into alcohol, a sesquiphosphate is obtained, in the form of a light white powder, containing 1½ times as much acid as the subphosphate.

The phosphate of strontian differs from the preceding in being soluble in an excess of its acid.

Phosphate of lime is very abundant in the native state. See APATITE. It likewise constitutes the chief part of the bones of all animals.

Phosphate of lime is very difficult to fuse, but in a glasshouse furnace it softens, and acquires the semitransparency and grain of porcelain. It is insoluble in water, but when well calcined, forms a kind of paste with it, as in making cupels. Besides this use of it, it is employed for polishing gems and metals, for absorbing grease from cloth, linen, or paper, and for preparing phosphorus. In medicine it has been strongly recommended against the rickets by Dr. Bonhomme of Avignon, either alone or combined with phosphate of soda. The *burnt hartshorn* of the shops is a phosphate of lime.

An acidulous phosphate of lime is found in human urine, and may be crystallized in small silky filaments, or shining scales, which unite together into something like the consistence of honey, and have a perceptibly acid taste. It may be prepared by partially decomposing the calcareous phosphate of bones by the sulphuric, nitric, or muriatic acid, or by dissolving that phosphate in phosphoric acid. It is soluble in water, and crystallizable. Exposed to the action of heat, it softens, liquefies, swells up, becomes dry, and may be fused into a transparent glass, which is insipid, insoluble, and unalterable in the air. In these characters it differs from the glacial acid of phosphorus. It is partly decomposable by charcoal, so as to afford phosphorus.

By pouring phosphate of soda into muriate of lime, Berzelius obtained a phosphate of lime consisting of acid 100, lime 84.53. The exact proportions are,

Phosphoric acid $= 9 = 100$
Lime $3.5 \times 2 = 7 = 78$ nearly.

The phosphate of potash is very deliquescent, and not crystallizable, but condensing into a kind of jelly. Like the preceding species, it first undergoes the aqueous fusion, swells, dries, and may be fused into a glass; but this glass deliquesces. It has a sweetish saline taste. The phosphate of soda is now commonly prepared by adding to the acidulous phosphate of lime as much carbonate of soda in solution as will fully saturate the acid. The carbonate of lime which precipitates, being separated by filtration, the liquid is duly evaporated so as to crystallize the phosphate of soda; but if there be not a slight excess of alkali, the crystals will not be large and regular. The crystals are rhomboidal prisms of different shapes; efflorescent; soluble in three parts of cold and 1½ of hot water. They are capable of being fused into an opaque white glass, which may be again dissolved and crystallized. It may be converted into an acidulous phosphate by an addition of acid, or by either of the strong acids, which partially, but not wholly, decompose it. As its taste is simply saline, without any thing disagreeable, it is much used as a purgative, chiefly in broth, in which it is not distinguishable from common salt. For this elegant addition to our pharmaceutical preparations, we are indebted to Dr. Pearson. In assays with the blowpipe it is of great utility; and it has been used instead of borax for soldering.

In crystals, this salt is composed, according to Berzelius, of phosphoric acid 20.33, soda 17.67, water 62.00; and in the dry state, of acid 53.48, soda 46.52. If it be represented by 1 atom of acid $= 9 +$ 2 atoms soda $= 8$, then 100 of the dry salt will consist of acid 53, base 47; and in the crystallized state, of

Water	24 atoms	27	61.4
Acid	1	9	20.4
Soda	2	8	18.2
			100.0

which presents a good accordance with the experimental results of the accurate Berzelius.

The phosphate of ammonia crystallizes in prisms with four regular sides, terminating in pyramids, and sometimes in bundles of small needles. Its taste is cool, saline pungent, and urinous. On the fire it comports itself like the preceding species, except that the whole of its base may be driven off by a continuance of the heat, leaving only the acid behind. It is but little more soluble in hot water than in cold, which takes up a fourth of its weight. It is pretty abundant in human urine. It is an excellent flux both for assays and the blowpipe, and in the fabrication of coloured glass and artificial gems.

Phosphate of magnesia crystallizes in irregular hexaëdral prisms, obliquely truncated; but is commonly pulverulent, as it effloresces very quickly. It requires fifty parts of water to dissolve it. Its taste is cool and sweetish. This salt too is found in urine. Fourcroy and Vauquelin have discovered it likewise in small quantity in the bones of various animals, though not in those of man. The best way of preparing it is by mixing equal parts of the solutions of phosphate of soda and sulphate of magnesia, and leaving them some time at rest, when the phosphate of magnesia will crystallize, and leave the sulphate of soda dissolved.

An ammoniaco-magnesian phosphate has been discovered in an intestinal calculus of a horse by Fourcroy, and since by Bartholdi, and likewise by the former in some human urinary calculi. See Calculus. Notwithstanding the solubility of the phosphate of ammonia, this triple salt is far less soluble than the phosphate of magnesia. It is partially decomposable into phosphorus by charcoal, in consequence of its ammonia.

The phosphate of glucine has been examined by Vauquelin, who informs us, that it is a white powder, or mucilaginous mass, without any perceptible taste; fusible, but not decomposable by heat; unalterable in the air, and insoluble unless in an excess of its acid.

It has been observed, that the phosphoric acid, aided by heat, acts upon silex; and we may add, that it enters into many artificial gems in the state of a saliceous phosphate. See Salt.

ACID (PINIC). In the colophony of France (rosin), derived in all probability from the *pinus maritima* or *pinaster*, M. Baup has found a substance which crystallizes in triangular plates, soluble in about four parts of alcohol, but insoluble in water. It reacts like an acid, and neutralizes alkaline matter. He calls it Pinic acid. *Annales de Chim. et de Phys.* xxxi.

ACID (PRUSSIC). This acid and its combinations have been lately investigated by MM. Gay Lussac and Vauquelin in France, and Mr. Porrett in England, who have happily succeeded in removing the veil which continued to hang over this department of chemistry.

To a quantity of powdered prussian blue

diffused in boiling water, let red oxide of mercury be added in successive portions till the blue colour is destroyed. Filter the liquid, and concentrate by evaporation till a pellicle appears. On cooling, crystals of prussiate or cyanide of mercury will be formed. Dry these, and put them into a tubulated glass retort, to the beak of which is adapted a horizontal tube about two feet long, and fully half an inch wide at its middle part. The first third part of the tube next the retort is filled with small pieces of white marble, the two other thirds with fused muriate of lime. To the end of this tube is adapted a small receiver, which should be artificially refrigerated. Pour on the crystals muriatic acid, in rather less quantity than is sufficient to saturate the oxide of mercury which formed them. Apply a very gentle heat to the retort. Prussic acid, named hydrocyanic by M. Gay Lussac, will be evolved in vapour, and will condense in the tube. Whatever muriatic acid may pass over with it, will be abstracted by the marble, while the water will be absorbed by the muriate of lime. By means of a moderate heat applied to the tube, the prussic acid may be made to pass successively along; and after being left some time in contact with the muriate of lime, it may be finally driven into the receiver. As the carbonic acid evolved from marble by the muriatic is apt to carry off some of the prussic acid, care should be taken to conduct the heat so as to prevent the distillation of this mineral acid.

Prussic acid thus obtained has the following properties. It is a colourless liquid, possessing a strong odour; and the exhalation, if incautiously snuffed up the nostrils, may produce sickness or fainting. Its taste is cooling at first, then hot, asthenic in a high degree, and a true poison. Its specific gravity at 44½°, is 0.7058; at 64° it is 0.6969. It boils at 81½°, and congeals at about 3°. It then crystallizes regularly, and affects sometimes the fibrous form of nitrate of ammonia. The cold which it produces, when reduced into vapour, even at the temperature of 68°, is sufficient to congeal it. This phenomenon is easily produced by putting a small drop at the end of a slip of paper or a glass tube. Though repeatedly rectified on pounded marble, it retains the property of feebly reddening paper tinged blue with litmus. The red colour disappears as the acid evaporates.

The specific gravity of its vapour, experimentally compared to that of air, is 0.9476. By calculation from its constituents, its true specific gravity comes out 0.9360, which differs from the preceding number by only one-hundredth part. This small density of prussic acid, compared with its great volatility, furnishes a new proof that the density of vapours does not depend upon the boiling point of the liquids that furnish them, but upon their peculiar constitution.

M. Gay Lussac analyzed this acid by introducing its vapour at the temperature of 86° into a jar, two-thirds filled with oxygen, over warm mercury. When the temperature of the mercury was reduced to that of the ambient air, a determinate volume of the gaseous mixture was taken and washed in a solution of potash, which abstracts the prussic acid, and leaves the oxygen. This gaseous mixture may, after this inspection, be employed without any chance that the prussic acid will condense, provided the temperature be not too low; but during M. Gay Lussac's experiments it was never under 71½°. A known volume was introduced into a Volta's eudiometer, with platina wires, and an electric spark was passed across the gaseous mixture. The combustion is lively, and of a bluish-white colour. A white prussic vapour is seen, and a diminution of volume takes place, which is ascertained by measuring the residue in a graduated tube. This being washed with a solution of potash or barytes, suffers a new diminution from the absorption of the carbonic acid gas formed. Lastly, the gas which the alkali has left is analyzed over water by hydrogen, and it is ascertained to be a mixture of nitrogen and oxygen, because this last gas was employed in excess.

The following are the results, referred to prussic acid vapour.

Vapour - - - -	100
Diminution after combustion -	78.5
Carbonic acid gas produced -	101.0
Nitrogen - - - - -	46.0
Hydrogen - - - - -	55.0

During the combustion a quantity of oxygen disappears, equal to about 1¼ of the vapour employed. The carbonic acid produced represents one volume; and the other fourth is supposed to be employed in forming water; for it is impossible to doubt that hydrogen enters into the composition of prussic acid. From the laws of chemical proportions, M. Gay Lussac concludes that prussic acid vapour contains just as much carbon as will form its own bulk of carbonic acid, half a volume of nitrogen, and half a volume of hydrogen. This result is evident for the carbon; and though, instead of 50 of nitrogen and hydrogen, which ought to be the numbers according to the supposition, he obtained 46 for the first, and 55 for the second, he ascribes the discrepancy to a portion of the nitrogen having combined with the oxygen to form nitric acid.

The density of carbonic acid gas being, according to M. Gay Lussac, 1.5196, and that of oxygen 1.1036, the density of the vapour of carbon is 1.5196 — 1.1036 = 0.4160. Hence

1 volume carbon - - = 0.4160
Half a volume of hydrogen = 0.0366
Half a volume of nitrogen = 0.4845

Sum = 0.9371

Thus, according to the analytical statement, the density of prussic vapour is 0.9371, and by direct experiment it was found to be 0.9476. It may therefore be inferred from this near coincidence, that prussic acid vapour contains one volume of the vapour of carbon, half a volume of nitrogen, and half a volume of hydrogen, condensed into one volume, and that no other substance enters into its composition.

M. Gay Lussac confirmed the above determination, analyzing prussic acid by passing its vapour through an ignited porcelain tube containing a coil of fine iron wire, which facilitates the decomposition of this vapour, as it does with ammonia. No trace of oxygen could be found in prussic acid. And again, by transmitting the acid in vapour over ignited peroxide of copper in a porcelain tube, he came to the same conclusion with regard to its constituents. They are,—

One volume of the vapour of carbon,
Half a volume of hydrogen,
Half a volume of nitrogen,
condensed into one volume; or in weight,—

Carbon - - -	44.39
Nitrogen - - -	51.71
Hydrogen - - -	3.90
	100.00

This acid, when compared with the other animal products, is distinguished by the great quantity of nitrogen it contains, by its small quantity of hydrogen, and especially by the absence of oxygen.

When this strong acid is kept in well-closed vessels, even though no air be present, it is sometimes decomposed in less than an hour. It has been occasionally kept 15 days without alteration; but it is seldom that it can be kept longer, without exhibiting signs of decomposition. It begins by assuming a reddish-brown colour, which becomes deeper and deeper, and it gradually deposits a considerable carbonaceous matter, which gives a deep colour to both water and acids, and emits a strong smell of ammonia. If the bottle containing the prussic acid be not hermetically sealed, nothing remains but a dry charry mass, which gives no colour to water. Thus a prussiate of ammonia is formed at the expense of a part of the acid, and an azoturet of carbon. When potassium is heated in prussic acid vapour mixed with hydrogen or nitrogen, there is absorption without inflammation, and the metal is converted into a grey spongy substance, which melts, and assumes a yellow colour.

Supposing the quantity of potassium employed capable of disengaging from water a volume of hydrogen equal to 50 parts, we find after the action of the potassium,—

1. That the gaseous mixture has experienced a diminution of volume amounting to 50 parts: 2. On treating this mixture with potash, and analysing the residue by oxygen, that 50 parts of hydrogen have been produced: 3. And consequently that the potassium has absorbed 100 parts of prussic vapour; for there is a diminution of 50 parts, which would obviously have been twice as great had not 50 parts of hydrogen been disengaged. The yellow matter is prussiate of potash; properly a pusside of potassium, analogous in its formation to the chloride and iodide, when muriatic and hydriodic gases are made to act on potassium.

The base of prussic acid thus divested of its acidifying hydrogen, might be called, agreeably to the same chemical analogy, prussine. M. Gay Lussac styles it cyanogen, because it is the principle which generates blue; or literally the blue-maker.

Like muriatic and hydriodic acids, this one contains half its volume of hydrogen. The only difference is, that the former have, in the present state of our knowledge, simple radicals, chlorine and iodine, while that of the latter is a compound of one volume vapour of carbon, and half a volume of nitrogen. This radical forms true cyanides with metals.

The cyanide of potassium gives a very alkaline solution in water, even when a great excess of hydrocyanic vapour has been present at its formation. In this respect it differs from the chlorides and iodides of that metal, which are perfectly neutral. Knowing the composition of prussic acid, and that potassium separates from it as much hydrogen as from water, it is easy to find its proportional number or equivalent to oxygen. We must take such a quantity of prussic acid that its hydrogen may saturate 10 of oxygen. Thus we find the prime equivalent of this acid to be 33.846; and subtracting the weight of hydrogen, there remains 32.52 for the equivalent of cyanogen or prussine. But if we reduce the numbers representing the volumes to the prime equivalents adopted in this Dictionary, viz. 0.75 for carbon, 0.125 for hydrogen, and 1.75 for nitrogen, we shall have the relation of volumes slightly modified. Since the fundamental combining ratio of oxygen to hydrogen in bulk is $\frac{1}{2}$ to 1, we must multiply the prime equivalent by half the specific gravity of oxygen, and we obtain the following numbers:—

$$1 \text{ volume car.} = 0.75 \times 0.5555 = 0.41663$$

$$\tfrac{1}{2} \text{ volume hyd.} = \frac{0.125 \times 0.5555}{2} = 0.03471$$

$$\tfrac{1}{2} \text{ volume nitr.} = \frac{1.75 \times 0.5555}{2} = 0.48610$$

$$\text{Sum} = 0.93744$$

Or, as is obvious by the above calculation, we may take 2 primes of carbon, 1 of hydrogen, and 1 of nitrogen, which directly added together will give the same results, since by so doing we merely take away the common multiplier 0.5555. Thus we have

2 primes carbon - -	1.500
1 prime hydrogen - -	0.125
1 prime nitrogen - -	1.750
	3.375

Which reduced to proportions per cent, give of

Carbon - - -	44.444
Hydrogen - - -	3.737
Nitrogen - - -	51.818
	100.000

Barytes, potash, and soda, combine with cyanogen, forming true cyanides of these alkaline oxydes; analogous to what are vulgarly called oxymuriates of lime, potash, and soda. The red oxide of mercury acts so powerfully on prussic acid vapour, when assisted by heat, that the compound which ought to result is destroyed by the heat disengaged. The same thing happens when a little of the concentrated acid is poured upon the oxide. A great elevation of temperature takes place, which would occasion a dangerous explosion if the experiment were made upon considerable quantities. When the acid is diluted, the oxide dissolves rapidly, with a considerable heat, and without the disengagement of any gas. The substance formerly called prussiate of mercury is generated, which when moist may, like the muriates, still retain that name; but when dry is a cyanide of the metal.

When the cold oxide is placed in contact with the acid, dilated into a gaseous form by hydrogen, its vapour is absorbed in a few minutes. The hydrogen is unchanged. When a considerable quantity of vapour has thus been absorbed, the oxide adheres to the side of the tube, and on applying heat, water is obtained. The hydrogen of the acid has here united with the oxygen of the oxide to form the water, while their two radicals combine. Red oxide of mercury becomes an excellent reagent for detecting prussic acid.

By exposing the dry cyanide of mercury to heat in a retort, the radical cyanogen is obtained. See Cyanogen.

On subjecting hydrocyanic, or prussic acid, to the action of a battery of 20 pairs of plates, much hydrogen is disengaged at the negative pole; and cyanogen at the positive, which remains dissolved in the acid. This compound should be regarded as a hypoprussic or prussous acid. Since potash by heat separates the hydrogen of the prussic acid, we see that in exposing a mixture of potash and animal matters to a high temperature, a true cyanide of potash is obtained, formerly called the prussian or phlogisticated alkali. When cyanide of potassium is dissolved in water, hydrocyanate of potash is produced, which is decomposed by the acids without generating ammonia or carbonic acid; but when cyanide of potash dissolves in water, no change takes place; and neither ammonia, carbonic acid, nor hydrocyanic vapour is given out, unless an acid be added. These are the characters which distinguish a metallic cyanide from the cyanide of an oxide.

From the experiments of M. Magendie it appears, that the pure hydrocyanic acid is the most violent of all poisons. When a rod dipped into it is brought in contact with the tongue of an animal, death ensues before the rod can be withdrawn. If a bird be held a moment over the mouth of a phial containing this acid, it dies. In the Annales de Chimie for 1814 we find this notice: M. B., professor of chemistry, left by accident on a table a flask containing alcohol impregnated with prussic acid; the servant, enticed by the agreeable flavour of the liquid, swallowed a small glass of it. In two minutes she dropped down dead, as if struck with apoplexy. The body was not examined.

"Scharinger, a professor at Vienna," says Orfila, "prepared six or seven months ago a pure and concentrated prussic acid; he spread a certain quantity of it on his naked arm, and died a little time thereafter."

Dr. Magendie has, however, ventured to introduce its employment into medicine. He found it beneficial against phthisis and chronic catarrhs. His formula is the following:—

Mix one part of the pure prussic or hydrocyanic acid of M. Gay Lussac with 8½ of water by weight. To this mixture he gives the name of medicinal prussic acid.

Of this he takes	1 gros.	or 59 gr. Troy.
Distilled water,	1 lb.	or 7560 grs.
Pure sugar,	1½ oz.	or 708¾ gr.

And mixing the ingredients well together, he administers a table-spoonful every morning and evening.

The simplest, and perhaps most economical, process which I know for obtaining hydrocyanic acid of moderate strength, for most chemical, and all medical purposes, is to dissolve ferroprussiate of potash in water, and to add to the solution, contained in a retort, as much sulphuric acid as there was salt employed. Distilling with a gentle heat, hydrocyanic acid is obtained. If it be tinged blue with a little iron, this may be separated either by filtration or redistillation. Another mode which I have found to afford an acid which keeps well, is to transmit a current of sulphuretted hydrogen gas through a solution of prussiate of mercury, till the whole metal be separated in the state of sulphuret. This subsides and leaves liquid hydrocyanic acid mixed with some sulphuretted hydrogen, which may be removed by agitation with carbonate of lead. This is merely a modification of Vauquelin's original process, in which sulphuretted hydrogen gas was made to act on the solid cyanide of mercury contained in a glass tube.

Hydrocyanic acid is formed in a great many chemical operations; as for instance, by transmitting ammoniacal gas over ignited charcoal contained in a tube; as also by heating in a glass tube closed at one end, a mixture of oxalate of ammonia, and oxalate of manganese. Formiate of ammonia decomposed in a glass retort, is converted into hydrocyanic acid and water.

One ten-thousandth part of prussic acid may be detected in water, by the addition of a few drops of solution of sulphate of iron. This test, although delicate, is surpassed by another, in which copper is used, and which will detect $\frac{1}{20.000}$ of hydrocyanic acid in water. We must render the liquid containing the hydrocyanic acid, slightly alkaline with potash; add a few drops of sulphate of copper, and afterwards sufficient muriatic acid to redissolve the excess of oxide of copper. The liquid will appear more or less milky, according to the quantity of hydrocyanic acid present.

A cat was poisoned by twelve drops of hydrocyanic acid, in sixty drops of water: the animal died one minute after having swallowed the poison. At the moment of its death, a vapour came from its throat smelling strongly of the acid, and a paper moistened with alkali, when held to it, was afterwards rendered blue by persulphate of iron. The animal was retained at the temperature of 50° F. for 18 hours, and then opened. The odour of prussic acid was readily perceived in the brain, spinal marrow, and thoracic organs. It was but slightly perceptible in the stomach, which contained nothing but mucus; but on cutting the organ in pieces, it was developed. The stomach was cut into pieces under water, and distilled with the water. When about an eighth of the liquid had passed over, it was mixed with potash and persulphate of iron, and soon gave a feeble blue tint, leaving no doubt of the presence of hydrocyanic acid. The test by copper gave it still more sensibly. The copper tested prussic acid also in the intestines; but the persulphate of iron did not.

Having been consulted by physicians and apothecaries concerning the strength of the dilute prussic or hydrocyanic acid employed in medicine, I instituted a series of experiments, to determine the relation between its specific gravity and quantity of real acid. The acid which I prepared with this view had a specific gravity = 0.957.

The following table comprehends their results.

Quantity of above Liquid Acid.	Sp. Gravity.	Real Acid per cent.
100.0	0.9570	16
66.6	0.9768	10.6
57.0	0.9815	9.1
50.0	0.9840	8.0
44.4	0.9870	7.3
40.0	0.9890	6.4
36.4	0.9900	5.8
33.3	0.9914	5.3
30.8	0.9923	5.0
28.6	0.9930	4.6
25.0	0.9940	4.0
22.2	0.9945	3.6
20.0	0.9952	3.2
18.2	0.9958	3.0
16.6	0.9964	2.7
15.4	0.9967	2.5
14.3	0.9970	2.3
13.3	0.9973	2.1
12.5	0.9974	2.0
11.8	0.9975	1.77
10.5	0.9978	1.68
10.0	0.9979	1.60

From the preceding table it is obvious, that for acid of specific gravity 0.996 or 0.997, such as is usually prescribed in medicine, the density is a criterion of greater nicety than can be conveniently used by the majority of practitioners. In fact, the liquid at 0.996 contains about double the quantity of real acid, which it does at 0.998. It is therefore desirable to have another test of the strength of this powerful and dangerous medicine, which shall be easier in use, and more delicate in its indications. Such a test is afforded by the red oxide of mercury, the common red precipitate of the shops. The prime equivalent of prussic acid is exactly one-eighth of that of the mercurial peroxide. But as the prussiate of mercury consists of two primes of acid to one of base, or is, in its dry crystalline state, a bicyanide, we have the relation of one to four in the formation of that salt, when we act on the peroxide with cold prussic acid. Hence we derive the following simple rule of analysis. To 100 grains, or any other convenient quantity of the acid, contained in a small phial, add in succession small quantities of the peroxide of mercury in fine powder, till it ceases to be dissolved on agitation. The weight of the red precipitate taken up being divided by four, gives a quotient representing the quantity of real prussic acid present. By weighing out beforehand, on a piece of paper, or a watch-glass, forty or fifty grains of the peroxide, the residual weight of it shows at once the quantity expended.

The operation may be always completed in five minutes, for the red precipitate dissolves as rapidly in the dilute prussic acid, with the aid of slight agitation, as sugar dissolves in water. Should the presence of muriatic acid be suspected, then the specific gravity of the liquid being compared with the numbers in the above table, and with the weight of peroxide dissolved, will show how far the suspicion is well founded. Thus, if 100 grains of acid, specific gravity 0.996, dissolve more than 12 grains of the red precipitate, we may be sure that the liquid has been contaminated with muriatic acid. Nitrate of silver, in common cases so valuable a reagent for muriatic acid, is unfortunately of little use here; for it gives with prussic acid a flocculent white precipitate, soluble in water of ammonia, and insoluble in nitric acid, which may be easily mistaken by common observers for the chloride of that metal. But the difference in the *volatility* of prussiate and muriate of ammonia may be had recourse to with advantage; the former exhaling at a very gentle heat, the latter requiring a subliming temperature of about 300° Fahrenheit. After adding ammonia in slight excess to the prussic acid, if we evaporate to dryness at a heat of 212°, we may infer from the residuary sal ammoniac the quantity of muriatic acid present.

The preceding table is the result of experiments which I made some time ago at Glasgow. I have lately verified its accuracy by experiments made at the Apothecaries' Hall, London, on their pure prussic acid. 100 grains of the bicyanide of mercury require for their conversion into bichloride (corrosive sublimate), 28.56 grains of chlorine, a quantity to be found in 100 grains of muriatic acid, specific gravity 1.1452. And as 100 grains of the bicyanide afford 20.6 of real prussic acid, they will furnish, by careful distillation on a water bath, a quantity of liquid acid, equivalent to 700 grains of the medicinal strength 0.996. By consulting my table of muriatic acid, published in this Dictionary, the quantity of it at any density, necessary for decomposing the above cyanide, will be immediately found; bearing in mind, that 31.5 = the prime equivalent of the salt, corresponds to 9 of chlorine.

Scheele found that prussic acid occasioned precipitates with only the following three metallic solutions; nitrates of silver, and mercury, and carbonate of silver. The first is white, the second black, the third green, becoming blue.

The hydrocyanates are all alkaline, even when a great excess of acid is employed in their formation; and they are decomposed by the weakest acids.

The hydrocyanate of ammonia crystallizes in cubes, in small prisms crossing each other, or in feathery crystals, like the leaves of a fern. Its volatility is such, that at the temperature of 71½° it is capable of bearing a pressure of 17.72 inches of mercury; and at 97° its elasticity is equal to that of the atmosphere. Unfortunately this salt is charred and decomposed with extreme facility. Its great volatility prevented M. Gay Lussac from determining the proportion of its constituents. Hydrocyanic acid converts iron or its oxide into prussian blue without the help either of alkalis or acids. Cyanogen acts on iron and water as iodine does on water and a base; and a CYANIC acid is formed, which dissolves a part of the iron, but also and at the same time hydrocyanic acid, which changes another part of the iron into prussian blue.

According to M. Vauquelin, very complex changes take place when gaseous cyanogen is combined with water, which leave the nature of cyanic acid involved in some obscurity. The water is decomposed; part of its hydrogen combines with one part of the cyanogen, and forms hydrocyanic acid; another part unites with the nitrogen of the cyanogen, and forms ammonia; and the oxygen of the water forms carbonic acid, with one part of the carbon of the cyanogen. Hydrocyanate, carbonate, and cyanate of ammonia, are also found in the liquid; and there still remain some carbon and nitrogen, which produce a brown deposit. Four and a half parts of water absorb one of gaseous cyanogen, which communicate to it a sharp taste and smell, but no colour. The solution in the course of some days, however, becomes yellow, and afterwards brown, in consequence of the intestine changes related above.

Hydrocyanic acid is separated from potash by carbonic acid; but when oxide of iron is added to the potash, M. Gay Lussac conceives that a triple compound, united by a much more energetic affinity, results, constituting what is usually called prussiate of potash, or prussiate of potash and iron. In illustration of this view, he prepared a hydrocyanate of potash and silver, which was quite neutral, and which crystallized in hexagonal plates. The solution of these crystals precipitates salts of iron and copper, white. Muriate of ammonia does not render it turbid; but muriatic acid, by disengaging hydrocyanic acid, precipitates chloride of silver. Sulphuretted hydrogen produces in it an analogous change. This compound, says M. Gay Lussac, is evidently the triple hydrocyanate of potash and silver; and its formation ought to be analogous to that of the other triple hydrocyanates. "And as we cannot doubt," adds he, "that hydrocyanate of potash and silver is in reality, from the mode of its formation, a compound of cyanide of silver and hydrocyanate of potash, I conceive that the hydrocyanate of potash and iron is likewise a compound of neutral hydrocyanate of potash, and subcyanide of iron, which I believe to be combined with hydrocyanic acid in the white precipitate. We may obtain it perfectly neutral, and then it does not decompose alum; but the hydrocyanate of potash, which is always alkaline, produces in it a light and flocculent precipitate of alumina. To the same excess of alkali we must ascribe the ochry colour of the precipitates which hydrocyanate of potash forms with the persalts of iron. Thus the remarkable fact, which ought to fix the attention of chemists, and which appears to me to overturn the theory of Mr. Porrett, is, that hydrocyanate of potash cannot become neutral except when combined with the cyanides."

ACID (CYANIC). Cyanate of potash may be procured in large quantity by heating to dull redness a very finely pulverized mixture of about equal parts of ferroprussiate of potash (well dried) and peroxide of manganese. If the heat be too great, we shall obtain little salt, because the deutoxide formed appears to change into protoxide at the expense of the cyanate. The mass is to be boiled with alcohol of moderate strength (0.840 sp. gr.), and on cooling, the salt separates in small plates, resembling chlorate of potash. It is insoluble in pure alcohol.

Cyanate of potash acted on by muriatic acid gas is converted into chloride of potassium, and much sal ammoniac is developed. Cyanate of potash by simple boiling in water becomes carbonate of potash. By both modes of analysis it seems to consist of potash 57.95, acid 42.05; whence the prime equivalent of the acid would seem to be 4.45: 100 of cyanate of silver contain 77.353 of oxide; a statement according nearly with the above equivalent.

The cyanates acted on by aqueous acids, give out their carbon of composition in the form of carbonic acid. In this way, the acid constituent of cyanate of silver was analyzed, and found to contain, carbon 35.334, azote 41.317, and oxygen 23.349; or cyanogen 76.471, oxygen 23.529. In fact, 2 atoms of carbon $= 1.5 + 1$, azote $= 1.75 + 1$, oxygen $= 1.$ give a sum $= 4.25$; which converted to *per cent.* proportions are, carbon 35.3, azote 41.7, oxygen $23.53 = 100$. Hence this acid has the same composition as the fulminic acid, though its properties are very different. *F. Wöhler*, *Annales de Chim. et de Phys.* xxvii. 196.

ACID (CHLOROCYANIC, or CHLOROPRUSSIC). M. Berthollet discovered, that when hydrocyanic acid is mixed with chlorine, it acquires new properties. Its odour is much increased. It no longer forms prussian blue with solutions of iron, but a green precipitate, which becomes blue by the addition of sulphurous acid. Hydrocyanic acid thus altered had acquired the name of *oxyprussic*, because it was supposed to have acquired oxygen. M. Gay Lussac subjected it to a minute examination, and found that it was a compound of equal volumes of chlorine and cyanogen, whence he proposed to distinguish it by the name of chlorocyanic acid. To prepare this compound, he passed a current of chlorine into solution of hydrocyanic acid, till it destroyed the colour of sulphate of indigo; and by agitating the liquid with mercury, he deprived it of the excess of chlorine. By distillation, afterwards, in a moderate heat, an elastic fluid is disengaged, which possesses the properties formerly assigned to *oxyprussic acid*. This, however, is not pure chlorocyanic acid, but a mixture of it with carbonic acid, in proportions which vary so much, as to make it difficult to determine them.

When hydrocyanic acid is supersaturated with chlorine, and the excess of this last is removed by mercury, the liquid contains chlorocyanic and muriatic acids. Having put mercury into a glass jar until it was 3-4ths full, he filled it completely with that acid liquid, and inverted the jar in a vessel of mercury. On exhausting the receiver of an air-pump containing this vessel, the mercury sunk in the jar, in consequence of the elastic fluid disengaged. By degrees the liquid itself was entirely expelled, and swam on the mercury on the outside. On admitting the air, the liquid could not enter the tube, but only the mercury, and the whole elastic fluid condensed, except a small bubble. Hence it was concluded that chlorocyanic acid was not a permanent gas, and that, in order to remain gaseous under the pressure of the air, it must be mixed with another gaseous substance.

The mixture of chlorocyanic and carbonic acids, has the following properties. It is colourless. Its smell is very strong. A very small quantity of it irritates the pituitory membrane, and occasions tears. It reddens litmus, is not inflammable, and does not detonate when mixed with twice its bulk of oxygen or hydrogen. Its density, determined by calculation, is 2.111. Its aqueous solution does not precipitate nitrate of silver, nor barytes water. The alkalis absorb it rapidly, but an excess of them is necessary to destroy its odour. If we then add an acid, a strong effervescence of carbonic acid is produced, and the odour of chlorocyanic acid is no longer perceived. If we add an excess of lime to the acid solution, ammonia is disengaged in abundance. To obtain the green precipitate from solution of iron, we must begin by mixing chlorocyanic acid with that solution. We then add a little potash, and at last a little acid. If we add the alkali before the iron, we obtain no green precipitate.

M. Gay Lussac deduces for the composition of chlorocyanic acid 1 volume of carbon $+ \frac{1}{2}$ a volume of azote $+ \frac{1}{2}$ a volume of chlorine; and when decomposed by the successive action of an alkali and an acid, it produces 1 volume of muriatic acid gas $+ 1$ volume of carbonic acid $+ 1$ volume of ammonia. The above three elements separately constituting two volumes, are condensed, by forming chlorocarbonic acid into one volume. And since one volume of chlorine, and one volume of cyanogen, produce two volumes of chlorocyanic acid, the density of this last ought to be the half of the sum of the densities of its two constituents. Density of chlorine is 2.421, density of cyanogen 1.801, half sum $= 2.111$, as stated above: Or the proportions by weight will be 3.25 = a prime equivalent of cyanogen + 4.5 = a prime of chlorine, giving the equivalent of chlorocyanic acid = 7.75.

Chlorocyanic acid exhibits with potassium almost the same phenomena as cyanogen. The inflammation is equally slow, and the gas diminishes as much in volume.

ACID (FERROPRUSSIC). Into a solution of the amber-coloured crystals, usually called *prussiate of potash*, pour hydrosulphuret of barytes, as long as any precipitate falls. Throw the whole on a filter, and wash the precipitate with cold water. Dry it; and having dissolved 100 parts in cold water, add gradually 30 of concentrated sulphuric acid; agitate the mixture, and set it aside to repose. The supernatant liquid is the ferroprussic acid of Mr. Porrett.

It has a pale lemon-yellow colour, but no smell.* Heat and light decompose it. Hydrocyanic acid is then formed, and white ferroprussiate of iron, which soon becomes blue. Its affinity for the bases enables it to displace acetic acid, without heat, from the acetates, and to form ferroprussiates.

When a saline solution contains a base with which the ferroprussic acid forms an insoluble compound, then, agreeably to Berthollet's principle, it is capable of supplanting its acid. When ferroprussiate of soda is exposed to voltaic electricity, the acid is evolved at the positive pole, with its constituent iron. Mr. Porrett considers this acid "as a compound of

4 atoms carbon = 30.00
1 atom azote = 17.50
1 atom iron = 17.50
1 atom hydrogen = 1.25
———
66.25"

This sum represents the weight of its prime equivalent. Ferroprussiate of potash, and of barytes, will each, therefore, according to him, consist of an atom of acid + an atom of base + two atoms of water.

Berzelius has shown that when sulphuretted hydrogen gas is transmitted over effloresced ferruginous prussiate of potash, heated in a glass tube by a spirit lamp, no hydrocyanic acid or water is produced; and that therefore the iron present in the salt is in the metallic state. On igniting dry ferroprussiate of potash along with peroxide of copper in a glass tube, the same chemist found that the gaseous products consisted of carbonic acid and azote in the proportion of three volumes of the former to two volumes of the latter. The same result was obtained from ferroprussiate of barytes. But as the potash and barytes of the above salts retain a portion of the carbonic acid, Berzelius next analyzed in the same way ferroprussiate of lead: he found that the gas collected towards the end of the operation, which was quite free from atmospheric air, was a mixture of two parts of carbonic acid, and one part of azote by volume. Hence the carbon and azote in these salts exist in the same proportions as in cyanogen; no water was produced. He finally concludes, that the dry ferroprussiates are composed of one atom of cyanide of iron and two atoms of cyanide of the other metal, potassium, barium, or lead; according as it is a ferroprussiate of potash, barytes, or lead, that is in question. Berzelius considers the ferroprussic or ferruretted chyazic acid of Mr. Porrett as a super-hydrocyanate of iron in an impure state. To obtain it pure he adopted the following method: he decomposed well-washed ferroprussiate of lead, under water, by a current of sulphuretted hydrogen gas, removing the excess of sulphuretted hydrogen with a small quantity of ferroprussiate of lead. The filtered fluid remained limpid and colourless in vacuo, leaving eventually a milk-white substance, which had no appearance of crystallization. This white matter has the following properties. It dissolves in water, to which it imparts an acid and agreeable flavour, but which is rather astringent. In contact with the air it deposits prussian blue, and assumes a greenish colour. It is inodorous, unless it has begun to decompose. When boiled, the liquid gives out hydrocyanic acid, and deposits a powder which becomes blue in contact with the air. It is necessary to boil it for some time to decompose it entirely. If cold water be saturated with dry super-hydrocyanate, and the solution be suffered to remain, it gives small transparent colourless crystals, which appear to contain water of crystallization. The crystals are apparently quadrilateral prisms in groups composed of concentric rays. Berzelius supposes these to be hydrocyanate, in which water replaces the second base that existed with the protoxide of iron. The white substance obtained by evaporation in vacuo does not appear to contain any water, or rather appears to be the super-hydrocyanate of protoxide of iron, without water of crystallization: for if it be distilled in a small and proper apparatus, it gives at first hydrocyanic acid; afterwards carbonate of ammonia and prussiate of ammonia. The production of ammonia in this experiment proves that what remains after the hydrocyanic acid, which is first evolved, is a hydrocyanate, and not a cyanide, because in the latter case it could only have given hydrocyanic acid and azotic gas. This substance may be kept without alteration in well closed vessels; but in the air it gradually decomposes, becomes at first greenish, afterwards blue, and finishes by being entirely converted into prussian blue.

On the relations of prussic acid and iron, the following observations by M. Vauquelin are curious. Hydrocyanic acid diluted with water, when placed in contact with iron in a glass vessel standing over mercury, quickly produces prussian blue, while, at the same time, hydrogen gas is given out. The greatest part of the prussian blue formed in that operation, remains in solution in the liquid. It appears only when the liquid comes in contact with the air. This shows us that prussian blue, at a minimum of oxidizement, is soluble in hydrocyanic acid. Dry hydrocyanic acid placed in contact with iron filings, undergoes no change in its colour nor smell; but the iron, which becomes agglutinated together at the bottom of the vessel, assumes a brown colour. After some days, the hydrocyanic acid being separated from the iron, and put in a small capsule under a glass jar, evaporated without leaving any residue. Therefore it had dissolved no iron. Hydrocyanic acid dissolved in water, placed in contact with hydrate of iron, obtained by means of potash, and washed with boiling water, furnished prussian blue immediately, without the addition of any acid. Scheele has made mention of this fact. When hydrocyanic acid is in excess on the oxide of iron, the liquor which floats over the prussian blue assumes, after some time, a beautiful purple colour. The liquor, when evaporated, leaves upon the edge of the dish circles of blue, and others of a purple colour, and likewise crystals of this last colour. When water is poured upon these substances, the purple-coloured body alone dissolves, and gives the liquid a fine purple colour. The substance which remains undissolved is prussian blue, which has been held in solution in the hydrocyanic acid. Some drops of chlorine let fall into this liquid change it to blue, and a greater quantity destroys its colour entirely. It is remarkable that potash poured into the liquid thus deprived of its colour, occasions no precipitate whatever.

Chemists will not fail to remark, from these experiments, that hydrocyanic acid does not form prussian blue directly with iron; but that, on the addition of water, (circumstances remaining the same,) prussian blue is produced. They will remark, likewise, that cyanogen united to water dissolves iron. This is confirmed by the inky taste which it acquires, by the disappearance of its colour, and by the residue which it leaves when evaporated; yet prussian blue is not formed. These experiments seem to show that prussian blue is a hydrocyanate, and not a cyanide.

The ammonia, and hydrocyanic acid, disengaged during the whole duration of the combustion of prussian blue, give a new support to the opinion, that this substance is a hydrocyanate of iron; and likewise the results which are furnished by the decomposition of prussian blue by heat in a retort, show clearly that it contains both oxygen and hydrogen, which are most abundant towards the end, long after any particles of adhering water must have been dissipated.

Such compounds we shall call ferroprussiates. M. Vauquelin and M. Thenard style them ferruginous prussiates.

Ferroprussiate of potash. Into an egg-shaped iron pot, brought to moderate ignition, project a mixture of good pearl-ash and dry animal matters, of which hoofs and horns are best, in the proportion of two parts of the former to five of the latter. Stir them well with a flat iron paddle. The mixture, as it calcines, will gradually assume a pasty form, during which transition it must be tossed about with much manual labour and dexterity. When the conversion into a chemical compound is seen to be completed by the cessation of the fetid animal vapours, remove the pasty mass with an iron ladle.

If this be thrown, while hot, into water, some of the prussic acid will be converted into ammonia, and of course the usual product diminished. Allow it to cool, dissolve it in water, clarify the solution by filtration or subsidence, evaporate, and, on cooling, yellow crystals of the ferroprussiate of potash will form. Separate these, redissolve them in hot water, and by allowing the solution to cool very slowly, larger and very regular crystals may be had. This salt is now manufactured in several parts of Great Britain, on the large scale; and therefore the experimental chemist need not incur the trouble and nuisance of its preparation. Nothing can exceed in beauty, purity, and perfection, the crystals of it prepared at Campsie, by Mr. Mackintosh.

An extemporaneous ferroprussiate of potash may at any time be made, by acting on prussian blue with pure carbonate of potash, prepared from the ignited bicarbonate or bitartrate. The blue should be previously digested at a moderate heat, for an hour or two, in its own weight of sulphuric acid diluted with five times its weight of water; then filtered, and thoroughly edulcorated by hot water, from the sulphuric acid. Of this purified prussian blue, add successive portions to the alkaline solution, as long as its colour is destroyed, or while it continues to change from blue to brown. Filter the liquid, saturate the slight alkaline excess with acetic acid, concentrate by evaporation, and allow it slowly to cool. Quadrangular bevelled crystals of the ferroprussiate of potash will form.

This salt is transparent, and of a beautiful lemon or topaz-yellow. Its specific gravity is 1.830. It has a saline, cooling, but not unpleasant taste. In large crystals it possesses a certain kind of toughness, and, in thin scales of elasticity. The inclination of the bevelled side to the plane of the crystal is about 135°. It loses about 13 per cent. of water, when moderately heated; and then appears of a white colour, as happens to the green copperas; but it does not melt like this salt. The crystals retain their figure till the heat verges on ignition. At a red heat it blackens, but, from the mode of its formation, we see that even that temperature is compatible with the existence of the acid, provided it be not too long continued. Water at 60° dissolves nearly one-third of its weight of the crystals; and at the boiling point, almost its own weight. It is not soluble in alcohol; and hence, chemical compilers, with needless scrupulosity, have assigned to that liquid the hereditary sinecure of screening the salt from the imaginary danger of atmospherical action. It is not altered by the air. Exposed in a retort to a strong red heat, it yields prussic acid, ammonia, carbonic acid, and a coaly residue consisting of charcoal, metallic iron, and potash. When dilute sulphuric or muriatic acid is boiled on it, prussic acid is evolved, and a very abundant white precipitate of protoprussiate of iron and potash falls, which afterwards, treated with liquid chlorine, yields a prussian blue, equivalent to fully one-third of the salt employed. Neither sulphuretted hydrogen, the hydrosulphurets, nor infusion of galls, produce any change on this salt. Red oxide of mercury acts powerfully on its solution at a moderate heat. Prussiate of mercury is formed, which remains in solution; while peroxide of iron and metallic mercury precipitate. Thus we see that a portion of the mercurial oxide is reduced, to carry the iron to the maximum of oxidizement.

The solution of ferroprussiate of potash is not affected by alkalis; but it is decomposed by almost all the salts of the permanent metals. The following table presents a view of the colours of the metallic precipitates thus obtained.

Solutions of	Give a
Manganese,	White precipitate.
Protoxide of iron,	Copious white.
Deutoxide of iron,	Copious clear blue.
Tritoxide of iron,	Copious dark blue.
Tin,	White.
Zinc,	White.
Antimony,	White.
Uranium,	Blood-coloured.
Cerium,	White.
Cobalt,	Grass-green.
Titanium,	Green.
Bismuth,	White.
Protoxide of copper,	White.
Deutoxide of copper,	Crimson-brown.
Nickel,	Apple-green.
Lead,	White.
Deutoxide of mercury,	White.
Silver,	White, passing to blue, in the air.
Palladium,	Olive.
Rhodium, Platinum, and Gold,	None.

If some of these precipitates, for example those of manganese or copper, be digested in a solution of potash, we obtain a ferroprussiate of potash and iron exactly similar to what is formed by the action of the alkaline solution on prussian blue. These precipitates, therefore, contain a quantity of iron.

The researches of Berzelius have shown that dry ferroprussiate of potash is truly a compound of one atom of cyanide of iron, with two atoms of cyanide of potassium. Its composition may therefore be stated as follows:

					With water of cryst^{n}.
1 atom	Iron	=	3.50	15.05	13.15
	Cyanogen	=	3.25	41.94	36.62
2 atoms	Cyanogen	=	6.50		
	Potassium	=	10.00	43.00	37.56
				Water	12.67
			23.25		100.00

In its crystallized state it contains three atoms of water, which makes its prime equivalent in that case 23.25 + 3.375 = 26.625. To convert this weight into ferroprussiate of lead, two atoms of nitrate of lead will be required = 41.5; so that one atom of nitrate of lead = 20.75, will be equivalent to $\frac{26.625}{2}$ = 13.3125 of crystals of ferroprussiate of potash. These 13.3125 parts of salt, by the action of nitrate of lead, afford 12.75 parts of nitre, which contain six of potash.

Ferroprussiate of soda may be prepared from prussian blue and pure soda, by a similar process to that prescribed for the preceding salt. It crystallizes in four-sided prisms, terminated by dihedral summits. They are yellow, transparent, have a bitter taste, and effloresce, losing in a warm atmosphere 37½ per cent. At 55° they are soluble in 4½ parts of water, and in a much less quantity of boiling water. As the solution cools, crystals separate. Their specific gravity is 1.458. They are said by Dr. John to be soluble in alcohol.

Its constituents are as follows:

1 atom	Iron	=	3.50	11.48
	Cyanogen	=	3.25	31.97
2 atoms	Cyanogen	=	6.50	
	Sodium	=	6.00	19.67
10 atoms water			11.25	36.88
			30.50	100.00

Ferroprussiate of lime may be easily formed from prussian blue and lime water. Its solution yields crystalline grains by evaporation.

It consists of:—

Iron	3.50	11.86
Cyanogen	9.75	33.05
Calcium	5.00	16.96
Water	11.25	38.13
	29.50	100.00

The preceding results, as also those of Berzelius on the ferrocyanide of lead being apparently discordant with those which I have stated in my paper, on the ultimate analysis of organic compounds (Phil. Trans. 1822), that a few words of explanation seem requisite. I found that an atom of nitrate of lead =

20.75, was, by the method of double decomposition, equivalent to 13.125 of crystallized ferrocyanide of potassium; whence I inferred that this was its atomic weight. According to Berzelius 20.75 parts of nitrate of lead, are equivalent to 13.3175 of the crystallized ferrocyanide of potassium. This difference, though small, would excite my surprise, considering the pains that I took, did not Berzelius show that ferroprussiate of lead is apt to carry down in its precipitation, a portion of nitrate of that metal, to which circumstance I ascribe the above discrepancy. By my experiments, 13.3175 grains of the crystallized ferroprussiate of potash afford 5.9 of potash, a result not wide of the truth. From 21 grains of ferrocyanide of lead, I obtained 2.625 grains of peroxide of iron, = 1.8375 of metallic iron, while, by Berzelius, the quantity of iron present is 1.87, a difference only in the second place of decimals. But, with regard to my products of igneous decomposition by peroxide of copper, I am satisfied that a portion of the azote combined with the oxygen of the peroxide, into a liquid compound, whence the gaseous analysis was vitiated. 20.75 parts of nitrate of lead, containing 14 of oxide, or 13 of metal, should yield by Berzelius 19.625 of ferrocyanide of lead; but I obtained 21, no doubt, in consequence of some nitrate falling down along with it.

From 13.125 grains of ferroprussiate of potash I obtained 1.69 of water, which is 12.87 *per cent*. Berzelius obtained from 12.4 to 12.9, his calculated atomic proportion being 12.67. Had it occurred to me to double the above product 1.69, then the number 3.38, being as nearly as possible 3 atoms of water = 3.375, would have unravelled all the intricacy, and have satisfied me that the complex constitution assigned by Berzelius was the true one, since it gave the fewest integer atoms of the constituents.

Ferroprussiate of barytes may be formed in the same way as the preceding species. Its crystals are rhomboidal prisms, of a yellow colour, and soluble in 2000 parts of cold water and 100 of boiling water.

According to Berzelius ferroprussiate of barytes consists of

Iron	3.500	9.62
Cyanogen	9.750	26.80
Barium	17.500	48.11
Water	5.625	15.47
	36.375	100.00

Ferroprussiate of strontian and *magnesia* have also been made.

Ferroprussiate of lead is formed by pouring neutral nitrate of lead into a solution of ferroprussiate of potash, taking care that the latter be in excess, in order to prevent the precipitation of nitrate of lead, which mixes with all the insoluble salts with base of oxide of lead, if there be an excess of nitrate of lead in the liquid from which they are deposited. The liquid remains perfectly neutral. The precipitate is white with a cast of yellow. Its composition is as follows:

Iron	3.50	8.92
Cyanogen	9.75	24.84
Lead	26.00	66.24
	39.25	100.00

In its state of ordinary dryness it contains 3 atoms of water.

Ferroprussiate of iron. We have already described the method of making the ferroprussiate of potash, which is the first step in the manufacture of this beautiful pigment. This is usually made by mixing together one part of the ferroprussiate of potash, one part of copperas, and four parts of alum, each previously dissolved in water. Prussian blue, mixed with more or less alumina, precipitates. It is afterwards dried on chalk stones, in a stove.

Pure prussian blue is best prepared by dropping a solution of ferroprussiate of iron into a solution of red muriate of iron, to which a slight excess of acid is previously added. The precipitate must be thoroughly washed and dried. It retains hygrometric moisture so strongly, that sulphuric acid *in vacuo* does not detach it.

Berzelius found that a portion of very dry prussian blue, when lighted at the edge, continued to burn by itself like *amadou*, giving a vapour which condensed on a funnel inverted over it; it was carbonate of ammonia. One hundred parts of such prussian blue left a residium of 60.14 parts of red oxide of iron, containing no potash.

When a solution of protoxide of iron is precipitated by prussiate of iron and potash, a white insoluble compound is formed which contains potash, and which, by absorbing oxygen, becomes blue. But it is well known that a salt with base of protoxide, which absorbs oxygen without there being an increase of acid, combines with an excess of base. Prussian blue, therefore, which is prepared by oxidation of the white precipitate, cannot be a neutral compound. Prussian blue thus prepared, has properties which it does not possess when differently prepared. It is soluble in pure water, but not in water which contains a certain quantity of any neutral salt. Thus there are evidently two blue combinations:— The one composed of 3 atoms of hydrocyanate of protoxide, and 4 atoms of hydrocyanate of deutoxide, in which the acid and oxygen of the second part is double that of the first; and another apparently composed of 1 atom of hydrocyanate of protoxide, and 2 atoms of hydrocyanate of deutoxide.

Ferroprussiate of ammonia is best prepared by acting on ferroprussiate of lead with caustic ammonia. The solution being evaporated *in vacuo*, a pulverulent salt is obtained. It is a hydrocyanate of protoxide of iron, combined with hydrocyanate of ammonia.

Pure prussian blue is a mass of an extremely deep blue colour, insipid, inodorous, and considerably denser than water. Neither water nor alcohol has any action on it. Boiling solutions of potash, soda, lime, barytes, and strontites, decompose it; forming on one hand soluble ferroprussiates with these bases, and on the other a residue of brown peroxide of iron, and a yellowish-brown sub-ferroprussiate of iron. This last, by means of sulphuric, nitric, or muriatic acids, is brought back to the state of a ferroprussiate, by abstracting the excess of iron oxide. Aqueous chlorine changes the blue to a green in a few minutes, if the blue be recently precipitated. Aqueous sulphuretted hydrogen reduces the blue ferroprussiate to the white protoferroprussiate.

Its igneous decomposition in a retort was executed by M. Vauquelin with minute attention. He regards it as a hydrocyanate or mere prussiate of iron; but the changes he describes are very complex. The general results of M. Vauquelin's analysis were hydrocyanic acid, hydrocyanate of ammonia, an oil soluble in potash, crystalline needles, which contained no hydrocyanic acid, but were merely carbonate of ammonia; and finally, a ferreous residue slightly attracted by the magnet, and containing a little undecomposed prussian blue.

Proust, in the Annales de Chimie, vol. lx. states, that 100 parts of prussian blue, without alum, yield 0.55 of red oxide of iron by combustion; and by nitric acid, 0.54. 100 of prussiate of potash and iron, he further says, afford, after digestion with sulphuric or nitric acid, 35 parts of prussian blue.

ACID (SULPHUROPRUSSIC); the sulphuretted chyazic acid of Mr. Porrett.

Dissolve in water one part of sulphuret of potash, and boil it for a considerable time with three or four parts of powdered prussian blue added at intervals. Sulphuret of iron is formed, and a colourless liquid containing the new acid combined with potash, mixed with hyposulphate and sulphate of potash. Render this liquid sensibly sour, by the addition of sulphuric acid. Continue the boiling for a little, and when it cools, add a little peroxide of manganese in fine powder, which will give the liquid a fine crimson colour. To the filtered liquid add a solution containing persulphate of copper, and protosulphate of iron, in the proportion of two of the former salt to three of the latter, until the crimson colour disappears. Sulphuroprussiate of copper falls. Boil this with a solution of potash, which will separate the copper. Distil the liquid mixed with sulphuric acid in a glass retort, and the peculiar acid will come over. By saturation with carbonate of barytes, and then throwing down this by the equivalent quantity of sulphuric acid, the sulphuroprussic acid is obtained pure.

It is a transparent and colourless liquid, possessing a strong odour, somewhat resembling acetic acid. Its specific gravity is only 1.022. It dissolves a little sulphur at a boiling heat. It then blackens nitrate of silver; but the pure acid throws down the silver white. By repeated distillations sulphur is separated and the acid is decomposed. Mr. Porrett, in the Annals of Phil. for May 1819, states the composition of this acid, as it exists in the sulphuretted chyazate of copper, to be—

2 atoms sulphur, = 4.000
2 carbon, = 1.508
1 azote, = 1.754
1 hydrogen, = 0.132

7.394

This is evidently an atom of the hydrocyanic acid of M. Gay Lussac, combined with 2 of sulphur. If to the above we add 9 for an atom of protoxide of copper, we have 16.394 for the prime equivalent of the metallic salt. When cyanogen and sulphuretted hydrogen were mixed together by M. Gay Lussac in his researches on the prussic principle, he found them to condense into yellow acicular crystals. Mr. Porrett has since remarked, that these crystals are not formed when the two gases are quite dry, but that they are quickly produced if a drop of water is passed up into the mixture. He does not think their solution in water corresponds to liquid sulphuretted chyazic acid; it does not change the colour of litmus; it has no effect on solutions of iron; it contains neither prussic nor sulphuretted chyazic acid; yet this acid is formed in it when it is mixed first with an alkali and then with an acid. The same treatment does not form any prussic acid.

M. Gay Lussac states, that the yellow needles obtained from the joint action of cyanogen and sulphuretted hydrogen, are "composed of one volume of cyanogen, and $1\frac{1}{2}$ volume of sulphuretted hydrogen."

The sulphuroprussiate of the red oxide of iron is a deliquescent salt, of a beautiful crimson colour. It may be obtained in a solid form by an atmosphere artificially dried.

Grotthus and Vogel, by fusing sulphur with ferroprussiate of potash, dissolving, filtering, and drying, obtained a substance which Berzelius has shown to be a sulphocyanide of potassium. Though he was not able to separate the sulphocyanogen, or sulphuret of cyanogen from the base, so as to have it in a separate state, yet he deduced its composition from experiments as being one atom of cyanogen, 3.25 + two atoms of sulphur, 4 = 7.25.

The sulphocyanide of potassium is composed of potassium one atom, 5 + sulphocyanogen one atom, 7.25 = 12.25.

Sulphuretted hydrocyanic acid consists of one atom of hydrogen, 0.125 + one atom of sulphocyanogen 7.25 = 7.375. On substituting selenium for sulphur, a selenio-cyanide of potassium was formed, perfectly analogous to the sulphocyanide.

Professor Zeise of Copenhagen describes (*Ann. de Ch. et Phys.* xxvi.) a new acid, and a new class of salts, produced by mixing in a wide-mouthed flask 16 measures of sulphuret of carbon with 45 measures of alcohol, and 100 measures of alcohol saturated with ammoniacal gas, at a temperature of 53° F. Two sets of crystals form. The first are finished in an hour or two, and have a feathery aspect. He considers them to be hydroxanthate of ammonia. The formation of the second set of crystals takes 30 or 40 hours. These are distinctly grouped in stars, have considerable lustre, and a prismatic form. They are hydrosulphuretted hydrosulphocyanate of ammonia. The flask or phial should be well closed with a ground stopper during the formation of these crystals, which are usually of a bright yellow colour. The salts of peroxide of copper produce, in the solution of that salt in water, a yellow flocculent precipitate. This seems to be a compound of ordinary hydrosulphocyanic acid with bisulphuret of copper. On dissolving 1 part of hydrosulphuretted hydrosulphocyanate of ammonia in about 180 of water, adding sulphuric or muriatic acids diluted with 16 parts of water, till there be an acid excess, and then dropping into this mixture, in successive small portions, a solution of red oxide of iron in sulphuric or muriatic acid, the liquid becomes a little dark and muddy, but it soon brightens up, with the formation in great abundance of crystalline white scales, which rapidly settle to the bottom. These crystals are to be taken out, and dried by pressure between folds of filtering paper. This matter contains no iron; but is a peculiar compound of sulphur, carbon, azote, and hydrogen, to which M. Zeise gives the name of crystalline hydrosulphuret of cyanogen, composed probably of 1 atom of azote, 2 of carbon, 4 of sulphur, and 2 of hydrogen.—Hydrosulphuretted hydrosulphocyanate of ammonia is represented as containing 1 atom ammonia, 2.125, 1 hydrosulphocyanic acid, 7.375, and 1 sulphuretted hydrogen 2.125 = 11.625.

ACID (PURPURIC). The excrements of the serpent *Boa Constrictor* consist of pure lithic acid. Dr. Prout found that on digesting this substance thus obtained, or from urinary calculi, in dilute nitric acid, an effervescence takes place, and the lithic acid is dissolved, forming a beautiful purple liquid. The excess of nitric acid being neutralized with ammonia, and the whole concentrated by slow evaporation, the colour of the solution becomes of a deeper purple; and dark red granular crystals, sometimes of a greenish hue externally, soon begin to separate in abundance. These crystals are a compound of ammonia with the acid principle in question. The ammonia was displaced by digesting the salt in a solution of caustic potash, till the red colour entirely disappeared. This alkaline solution was then gradually dropped into dilute sulphuric acid, which, uniting with the potash, left the acid principle in a state of purity.

This acid principle is likewise produced from lithic acid by chlorine, and also, but with more difficulty, by iodine. Dr. Prout, the discoverer of this new acid, has, at the suggestion of Dr. Wollaston, called it purpuric acid, because its saline compounds have for the most part a red or purple colour.

This acid, as obtained by the preceding process, usually exists in the form of a very fine powder, of a slightly yellowish or cream colour; and when examined with a magnifier, especially under water, appears to possess a pearly lustre. It has no smell, nor taste. Its spec. grav. is considerably above water. It is scarcely soluble in water. One-tenth of a grain, boiled for a considerable time in 1000 grains of water, was not entirely dissolved. The water, however, assumed a purple tint, probably, Dr. Prout thinks, from the formation of a little purpurate of ammonia. Purpuric acid is insoluble in alcohol and ether. The mineral acids dissolve it only when they are concentrated. It does not affect litmus paper. By igniting it in contact with oxide of copper, he determined its composition to be,

2 atoms	hydrogen,	0.250	-	4.54
2	carbon,	1.500	-	27.27
2	oxygen,	2.000	-	36.36
1	azote,	1.750	-	31.81
		5.50		99.98

Purpuric acid combines with the alkalis, alkaline earths, and metallic oxides. It is capable of expelling carbonic acid from the alkaline carbonates by the assistance of heat, and does not combine with any other acid. These are circumstances sufficient, as Dr. Wollaston observed, to distinguish it from an oxide, and to establish its character as an acid.

Purpurate of ammonia crystallizes in quadrangular prisms, of a deep garnet-red colour. It is soluble in 1500 parts of water at 60°, and in much less at the boiling temperature. The solution is of a beautiful deep carmine, or rose-red colour. It has a slightly sweetish taste, but no smell. Purpurate of potash is much more soluble; that of soda is less; that of lime is nearly insoluble: those of strontian and lime are slightly soluble. All the solutions have the characteristic colour. Purpurate of magnesia is very soluble; and in solution, of a very beautiful colour. A solution of acetate of zinc produces with purpurate of ammonia a solution and precipitate of a beautiful gold-yellow colour; and a most brilliant iridescent pellicle, in which green and yellow predominate, forms on the surface of the solution. Dr. Prout conceives the salts to be anhydrous, or void of water, and composed of two atoms of acid and one of base. The purpuric acid and its compounds probably constitute the bases of many animal and vegetable colours. The well known pink sediment which generally appears in the urine of those labouring under febrile affections appears to owe its colour chiefly to the purpurate of ammonia, and perhaps occasionally to the purpurate of soda.

The solution of lithic acid in nitric acid stains the skin of a permanent colour, which becomes of a deep purple on exposure to the sun. These apparently sound experimental deductions of Dr. Prout have been called in question by M. Vauquelin; but Dr. Prout ascribes M. Vauquelin's failure in attempting to procure purpuric acid, to his having operated on an impure lithic acid. I think entire confidence may be put in Dr. Prout's experiments. He says that it is difficult to obtain purpuric acid from the lithic acid of urinary concretions.—*Phil. Trans. for* 1818, *and Annals of Phil.* vol. xiv.

ACID (PYROCITRIC.) When citric acid is put to distil in a retort, it begins at first by melting; the water of crystallization separates almost entirely from it by a continuance of the fusion, then it assumes a yellowish tint, which gradually deepens. At the same time there is disengaged a white vapour which goes over, to be condensed in the receiver. Towards the end of the calcination a brownish vapour is seen to form, and there remains in the bottom of the retort a light very brilliant charcoal.

The product contained in the receiver consists of two different liquids. One, of an amber-yellow colour, and an oily aspect, occupies the lower part; another, colourless and liquid like water, of a very decided acid taste, floats above. After separating them from one another, we perceive that the first has a very strong bituminous odour, and an acid and acrid taste; that it reddens powerfully the tincture of litmus, but that it may be deprived almost entirely of that acidity by agitation with water, in which it divides itself into globules, which soon fall to the bottom of the vessel, and are not long in uniting into one mass, in the manner of oils heavier than water.

In this state it possesses some of the properties of these substances; it is soluble in alcohol, ether, and the caustic alkalis. However, it does not long continue thus; it becomes acid, and sometimes even it is observed to deposit, at the end of some days, white crystals, which have a very strong acidity; if we then agitate it anew with water, it dissolves in a great measure, and abandons a yellow or brownish pitchy matter, of a very obvious empyreumatic smell, and which has much analogy with the oil obtained in the distillation of other vegetable matters. The same effect takes place when we keep it under water; it diminishes gradually in volume, the water acquires a sour taste, and a thick oil remains at the bottom of the vessel.

This liquid may be regarded as a combination (of little permanence indeed) of the peculiar acid with the oil formed in similar circumstances.

As to the liquid and colourless portion which floated over this oil, it was ascertained to contain no citric acid *carried over*, nor acetic acid; first, because on saturating it with carbonate of lime, a soluble calcareous salt was obtained; and, secondly, because this salt, treated with sulphuric acid, evolved no odour of acetic acid.

From this calcareous salt the lime was separated by oxalic acid; or the salt itself was decomposed with acetate of lead, and the precipitate treated with sulphuretted hydrogen. By these two processes, this new acid was separated in a state of purity.

Properties of the pyrocitric acid.—This acid is white, inodorous, of a strongly acid taste. It is difficult to make it crystallize in a regular manner, but it is usually presented in a white mass, formed by the interlacement of very fine small needles. Projected on a hot body it melts, is converted into white very pungent vapours, and leaves some traces of carbon. When heated in a retort, it affords an oily-looking acid, and yellowish liquid, and is partially decomposed. It is very soluble in water and in alcohol; water at the temperature of 10° C. (50° F.) dissolves one-third of its weight. The watery solution has a strongly acid taste, it does not precipitate lime or barytes water, nor the greater part of metallic solutions, with the exception of acetate of lead and protonitrate of mercury. With the oxides it forms salts possessing properties different from the citrates.

The pyrocitrate of potash crystallizes in small needles, which are white, and unalterable in the air. It dissolves in about 4 parts of water. Its solution gives no precipitate with the nitrate of silver, or of barytes; whilst that of the citrate of barytes forms precipitates with these salts.

The pyrocitrate of lime directly formed, exhibits a white crystalline mass, composed of needles, opposed to each other, in a ramification form. This salt has a sharp taste. It dissolves in 25 parts of water at 50° Fahr. It contains 30 *per cent.* of water of crystallization; and is composed, in its dry state, of

Pyrocitric acid,	34
Lime,	66

The solution of the pyrocitric acid saturated with barytes water lets fall, at the end of some hours, a very white crystalline powder, which is pyrocitrate of barytes. This salt is soluble in 150 parts of cold water, and in 50 of boiling water. Two grammes of this salt decomposed by sulphuric acid, furnished 1.7 of sulphate of barytes, which gives for its composition,

Pyrocitric acid,	43.9
Barytes,	56.1

The pyrocitrate of lead is easily obtained by pouring pyrocitrate of potash into a solution of acetate of lead. The pyrocitrate of lead presents itself under the form of a white gelatinous semitransparent mass, which becomes dry in the air, shrinking like gelatinous alumina, to which, in its physical characters, it has much analogy. It contains 8 *per cent.* of water, and is formed of

Pyrocitric acid,	33.4
Protoxide of lead,	66.6

Knowing the composition of pyrocitrate of lead, it was employed, by ignition with oxide of copper, to determine that of the acid itself, which is stated as being

Carbon,	47.5
Oxygen,	43.5
Hydrogen,	9.0
	100.0

The proportion of the elements of this acid is very different then from that which MM. Gay Lussac, Thenard, and Berzelius have found for citric acid. But what is remarkable, says M. Lassaigne, its capacity for saturation is nearly the same as that of citric acid, as we may see by casting our eyes on the analyses of the pyrocitrates of lime, barytes, and lead, which we have given, and which we have convinced ourselves of by frequent verification. Nevertheless, in the combination of this new acid, the ratio of the oxygen of the oxide to the oxygen of the acid is in a different proportion from that admitted for the neutral citrates: we observe that in the pyrocitrates the oxygen of the base is to that of the acid as 1 to 3.07; whilst in the citrates it is as 1 to 4.916.

The author seems here to have miscalculated strangely. Taking his analysis of pyrocitrate of lime and of pyrocitric acid, we have

34 acid, which contain 14.6 of oxygen,
66 lime, - 18.6 of oxygen;

so that the oxygen of the base is to that of the acid as 1 to 0.785, instead of 1 to 3.07.

In fact, the pyrocitrate of lime result makes the atom of acid, referred to Dr. Wollaston's scale, to be 18.3; that for pyrocitrate of barytes makes it 76.5, and that for pyrocitrate of lead, 70. The only supposition we can form is, that the numbers for the calcareous salt are inverted in the *Journal de Pharmacie*; and that they ought to be,

Pyrocitric acid,	66
Lime,	34

In this case the atom comes out 69.0; a tolerable accordance with the above. Were the equivalent of the acid 66.25, then it might consist of

Carbon,	4 atoms	=	30.00	45.27
Oxygen,	3 -	=	30.00	45.27
Hydrogen,	5 -	=	6.25	9.46
			66.25	100.00

ACID (PYROLIGNOUS). In the destructive distillation of any kind of wood, an acid is obtained, which was formerly called *acid spirit of wood*, and since, pyrolignous acid. Fourcroy and Vauquelin showed that this acid was merely the acetic, contaminated with empyreumatic oil and bitumen. See Acetic Acid.

Under acetic acid will be found a full account of the production and purification of pyrolignous acid. M. Monge discovered, about five years ago, that this acid has the property of preventing the decomposition of animal substances. But I have lately learned that Mr. William Dinsdale, of Field Cottage, Colchester, three years prior to the date of M. Monge's discovery, did propose to the Lords Commissioners of the Admiralty, to apply a pyrolignous acid, (prepared out of the contact of iron vessels, which blacken it), to the purpose of preserving animal food, wherever their ships might go. As this application may in many cases afford valuable anti-scorbutic articles of food, and thence be eminently conducive to the health of seamen, it is to be hoped that their lordships will, ere long, carry into effect Mr. Dinsdale's ingenious plan, as far as shall be deemed necessary. It is sufficient to plunge meat for a few moments into this acid, even slightly empyreumatic, to preserve it as long as you please. "Putrefaction," it is said, "not only stops, but retrogrades." To the empyreumatic oil a part of this effect has been ascribed; and hence has been accounted for, the agency of smoke in the preservation of tongues, hams, herrings, &c. Dr. Jorg of Leipsic has entirely recovered several anatomical preparations from incipient corruption by pouring this acid over them. With the empyreumatic oil or tar he has smeared pieces of flesh already advanced in decay, and notwithstanding that the weather was hot, they soon became dry and sound. To the above statements Mr. Ramsay of Glasgow, an eminent manufacturer of pyrolignous acid, and well known for the purity of his vinegar from wood, has recently added the following facts in the 5th number of the Edinburgh Philosophical Journal. If fish be simply dipped in redistilled pyrolignous acid, of the specific gravity 1.012, and afterwards dried in the shade, they preserve perfectly well. On boiling herrings treated in this manner, they were very agreeable to the taste, and had nothing of the disagreeable empyreuma which those of his earlier experiments had, which were steeped for three hours in the acid. A number of very fine haddocks were cleaned, split, and slightly sprinkled with salt for six hours. After being drained, they were dipped for about three seconds in pyrolignous acid, then hung up in the shade for six days. On being broiled, the fish were of an uncommonly fine flavour, and delicately white. Beef treated in the same way had the same flavour as Hamburgh beef, and kept as well. Mr. Ramsay has since found, that his perfectly purified vinegar, specific gravity 1.034, being applied by a cloth or sponge to the surface of fresh meat, makes it keep sweet and sound for several days longer in summer than it otherwise would. Immersion for a minute in his purified common vinegar, specific gravity 1.009, protects beef and fish from all taint in summer, provided they be hung up and dried in the shade. When, by frequent use, the pyrolignous acid has become impure, it may be clarified by beating up twenty gallons of it with a dozen of eggs in the usual manner, and heating the mixture in an iron boiler. Before boiling, the eggs coagulate, and bring the impurities to the surface of the boiler, which are of course to be carefully skimmed off. The acid must be immediately withdrawn from the boiler, as it acts on iron.

ACID (PYROLITHIC). When uric acid concretions are distilled in a retort, silvery white plates sublime. These are pyrolithate of ammonia. When their solution is poured into that of subacetate of lead, a pyrolithate of lead falls, which, after proper washing, is to be shaken with water, and decomposed by sulphuretted hydrogen gas. The supernatant liquid is now a solution of pyrolithic acid, which yields small acicular crystals by evaporation. By heat, these melt and sublime in white needles. They are soluble in four parts of cold water, and the solution reddens vegetable blues. Boiling alcohol dissolves the acid, but on cooling it deposits it, in small white grains. Nitric acid dissolves without changing it. Hence, pyrolithic is a different acid from the lithic, which, by nitric acid, is convertible into purpurate of ammonia. The pyrolithate of lime crystallizes in stalactites, which have a bitter and slightly acrid taste. It consists of 91.4 acid + 8.6 lime. Pyrolithate of barytes is a nearly insoluble powder. The salts of potash, soda, and ammonia, are soluble, and the former two crystallizable. At a red heat, and by passing it over ignited oxide of copper, it is decomposed, into oxygen 44.32, carbon 28.29, azote 16.84, hydrogen 10.

ACID (PYROMALIC). When malic or sorbic acid, for they are the same, is distilled in a retort, an acid sublimate, in white needles, appears in the neck of the retort, and an acid liquid distils into the receiver. This liquid, by evaporation, affords crystals, constituting a peculiar acid, to which the above name has been given.

They are permanent in the air, melt at 118° Fahr., and on cooling form a pearl-coloured mass of diverging needles. When thrown on red-hot coals, they completely evaporate in an acrid, cough-exciting smoke. Exposed to a strong heat in a retort, they are partly sublimed in needles, and are partly decomposed. They are very soluble in strong alcohol, and in double their weight of water, at the ordinary temperature. The solution reddens vegetable blues, and yields white flocculent precipitates with acetate of lead and nitrate of mercury; but produces no precipitate with lime water. By mixing it with barytes water, a white powder falls, which is redissolved by dilution with water, after which, by gentle evaporation, the pyromalate of barytes may be obtained in silvery plates. These consist of 100 acid, and 185.142 barytes, or in prime equivalents, of 5.25 + 9.75.

Pyromalate of potash may be obtained in feather-formed crystals, which deliquesce. Pyromalate of lead forms first a white flocculent precipitate, soon passing into a semi-transparent jelly, which, by dilution and filtration from the water, yields brilliant pearly-looking needles. The white crystals, that sublime in the original distillation, are considered by M. Lassaigne as a peculiar acid.

ACID (PYROMUCIC). This acid, discovered in 1818 by M. Houton Labillardière, is one of the products of the distillation of mucic acid. When we wish to procure it, the operation must be performed in a glass retort furnished with a receiver. The acid is formed in the brown liquid, which is produced along with it, and which contains water, acetic acid, and empyreumatic oil; a very small quantity of the pyromucic acid remaining attached to the vault of the retort, under the form of crystals. These crystals being coloured are added to the brown liquor, which is then diluted with 3 or 4 times its quantity of water, in order to throw down a certain portion of oil. The whole is next filtered, and evaporated to a suitable degree. A great deal of acetic acid is volatilized, and then the new acid crystallizes. On decanting the mother waters, and concentrating them farther, they yield crystals anew; but as these are small and yellowish, it is necessary to make them undergo a second distillation to render them susceptible of being perfectly purified by crystallization. 150 parts of mucic acid furnish about 60 of brown liquor, from which we can obtain 8 to 10 of pure pyromucic acid.

This acid is white, inodorous, of a strongly acid taste, and a decided action on litmus. Exposed to heat in a retort it melts at the temperature of 266° F., then volatilizes, and condenses into a liquid, which passes on cooling into a crystalline mass, covered with very fine needles. It leaves very slight traces of residuum in the bottom of the retort.

On burning coals, it instantly diffuses white pungent vapours. Air has no action on it. Water at 60° dissolves $\frac{1}{28}$ of its weight. Boiling water dissolves it much more abundantly, and on cooling abandons a portion of it, in small elongated plates, which cross in every direction.

Subacetate of lead is the only salt of whose oxide it throws down a portion.

It consists in 100 parts of

Carbon,	52.118
Oxygen,	45.806
Hydrogen,	2.111

This acid unites readily to the salifiable bases, and forms,

With potash, a salt very soluble in water and alcohol, deliquescent, and which, evaporated to a pellicle, congeals into a granular mass;

With soda, a salt less deliquescent and less soluble in water and alcohol than the preceding; but which crystallizes with difficulty;

With barytes, strontian, and lime, salts soluble in water, and a little more so in hot than in cold, insoluble in alcohol, and easily obtained in crystals, which are permanent in the air;

With ammonia, a salt soluble in water, which, by evaporation of the liquid, loses a portion of its base, becomes acid, and then crystallizes with facility;

With protoxide of lead, a neutral soluble salt, which possesses remarkable properties. This salt is obtained by putting liquid pyromucic acid in contact with moist carbonate of lead. When we evaporate the solution, the salt collects at the surface in transparent liquid globules, of a brownish colour, and an oily aspect; which a little after they are removed assume the softness and toughness of pitch, and finally become solid, opaque, and whitish. This property belongs also to succinate of lead.

The alkaline pyromucates occasion scarcely any turbidity in the solutions of the metallic salts, if we except those of the peroxide of iron, of the peroxide of mercury, the subacetate of lead, and the protonitrate of tin. The deposit formed in the salts of iron is a yellow similar to that of turbeth mineral.

In all the salts in the neutral state, the quantity of oxygen in the oxide is to the quantity in the acid as 1 to 13, which number therefore represents the equivalent weight of pyromucic acid.—*Annales de Chim. et de Phys.* ix. 365.

ACID (PYROTARTARIC). Into a coated glass retort introduce tartar, or rather tartaric acid, till it is half full, and fit to it a tubulated receiver. Apply heat, which is to be gradually raised to redness. Pyrotartaric acid of a brown colour, from impurity, is found in the liquid products. We must filter these through paper previously wetted, to separate the oily matter. Saturate the liquid with carbonate of potash; evaporate to dryness; redissolve, and filter through clean moistened paper. By repeating this process of evaporation, solution, and filtration, several times, we succeed in separating all the oil. The dry salt is then to be treated in a glass retort, at a moderate heat, with dilute sulphuric acid. There passes over into the receiver, first of all a liquor containing evidently acetic acid; but towards the end of the distillation, there is condensed, in the vault of the retort, a white and foliated sublimate, which is the pyrotartaric acid, perfectly pure.

It has a very sour taste, and reddens powerfully the tincture of turnsole. Heated in an open vessel, the acid rises in a white smoke, without leaving the charcoaly residuum which is left in a retort. It is very soluble in water, from which it is separated in crystals by spontaneous evaporation. The bases combine with it, forming pyrotartrates, of which those of potash, soda, ammonia, barytes, strontites, and lime, are very soluble. That of potash is deliquescent, soluble in alcohol, capable of crystallizing in plates, like the acetate of potash. This pyrotartrate precipitates both acetate of lead and nitrate of mercury, whilst the acid itself precipitates only the latter. Rose is the discoverer of this acid, which was formerly confounded with the acetic.

ACID (ROSASIC). There is deposited from the urine of persons labouring under intermittent and nervous fevers, a sediment of a rose colour, occasionally in reddish crystals. This was first discovered to be a peculiar acid by M. Proust, and afterwards examined by M. Vauquelin. This acid is solid, of a lively cinnabar hue, without smell, with a faint taste, but reddening litmus very sensibly. On burning coal it is decomposed into a pungent vapour, which has not the odour of burning animal matter. It is very soluble in water, and it even softens in the air. It is soluble in alcohol. It forms soluble salts with potash, soda, ammonia, barytes, strontites, and lime. It gives a slight rose-coloured precipitate with acetate of lead. It also combines with lithic acid, forming so intimate a union, that the lithic acid in precipitating from urine carries the other, though a deliquescent substance, down along with it. It is obtained pure by acting on the sediment of urine with alcohol. See ACID (PURPURIC.)

ACID (SACLACTIC). See ACID (MUCIC).

ACID (SEBACIC). Subject to a considerable heat 7 or 8 pounds of hog's lard, in a stoneware retort capable of holding double the quantity, and connect its beak by an adopter with a cooled receiver. The condensible products are chiefly fat, altered by the fire, mixed with a little acetic and sebacic acids. Treat this product with boiling water several times, agitating the liquor, allowing it to cool, and decanting each time. Pour at last into the watery liquid, solution of acetate of lead in excess. A white flocculent precipitate of sebate of lead will instantly fall, which must be collected on a filter, washed and dried. Put the sebate of lead into a phial, and pour upon it its own weight of sulphuric acid, diluted with five or six times its weight of water. Expose this phial to a heat of about 212°. The sulphuric acid combines with the oxide of lead, and sets the sebacic acid at liberty. Filter the whole while hot. As the liquid cools, the sebacic acid crystallizes, which must be washed, to free it completely from the adhering sulphuric acid. Let it be then dried at a gentle heat.

The sebacic acid is inodorous; its taste is slight, but it perceptibly reddens litmus paper; its specific gravity is above that of water, and its crystals are small white needles of little coherence. Exposed to heat, it melts like fat, is decomposed, and partially evaporated. The air has no effect upon it. It is much more soluble in hot than in cold water; hence boiling water saturated with it assumes a nearly solid consistence on cooling. Alcohol dissolves it abundantly at the ordinary temperature.

With the alkalis it forms soluble neutral salts; but if we pour into their concentrated solutions, sulphuric, nitric, or muriatic acids, the sebacic is immediately deposited in large quantity. It affords precipitates with the acetates and nitrates of lead, mercury, and silver.

Such is the account given by M. Thenard of this acid, in the 3d volume of his Traité de Chimie, published in 1815. Berzelius, in 1816, published an elaborate dissertation, to prove that M. Thenard's new sebacic acid was only the benzoic, contaminated by the fat, from which, however, it may be freed, and brought to the state of common benzoic acid. M. Thenard takes no notice of M. Berzelius whatever, but concludes his account by stating, that it has been known only for twelve or thirteen years, and that it must not be confounded with the acid formerly called sebacic, which possesses a strong disgusting odour, and was merely acetic or muriatic acid; or fat which had been changed in some way or other, according to the process used in the preparation.

ACID (SELENIC). See SELENIUM.

ACID (SILICATED FLUORIC). See ACID (FLUORIC).

ACID (SORBIC). The acid of apples called malic, may be obtained most conveniently and in greatest purity from the berries of the mountain ash, called *sorbus* or *pyrus aucuparia*, and hence the present name, sorbic acid. This was supposed to be a new and peculiar acid by Mr. Donovan and M. Vauquelin, who wrote good dissertations upon it. But it now appears that the sorbic and *pure* malic acids are identical.

Bruise the ripe berries in a mortar, and then squeeze them in a linen bag. They yield nearly half their weight of juice, of the specific gravity of 1.077. This viscid juice, by remaining for about a fortnight in a warm temperature, experiences the vinous fermentation, and would yield a portion of alcohol. By this change, it has become bright, clear, and passes easily through the filter, while the sorbic acid itself is not altered. Mix the clear juice with filtered solution of acetate of lead. Separate the precipitate on a filter, and wash it with cold water. A large quantity of boiling water is then to be poured upon the filter, and allowed to drain into glass jars. At the end of some hours, the solution deposits crystals of great lustre and beauty. Wash these with cold water, dissolve them in boiling water, filter, and crystallize. Collect the new crystals, and boil them for half an hour in 2.3 times their weight of sulphuric acid, specific gravity 1.090, supplying water as fast as it evaporates, and stirring the mixture diligently with a glass rod. The clear liquor is to be decanted into a tall narrow glass jar, and while still hot, a stream of sulphuretted hydrogen is to be passed through it. When the lead has been all thrown down in a sulphuret, the liquid is to be filtered, and then boiled in an open vessel to dissipate the adhering sulphuretted hydrogen. It is now a solution of sorbic acid.

When it is evaporated to the consistence of a syrup, it forms mammelated masses of a crystalline structure. It still contains a considerable quantity of water, and deliquesces when exposed to the air. Its solution is transparent, colourless, void of smell, but powerfully acid to the taste. Lime and barytes waters are not precipitated by solution of the sorbic acid, although the sorbate of lime is nearly insoluble. One of the most characteristic properties of this acid is the precipitate which it gives with the acetate of lead, which is at first white and flocculent, but afterwards assumes a brilliant crystalline appearance. With potash, soda, and ammonia, it forms crystallizable salts containing an excess of acid. That of potash is deliquescent. Sorbate of barytes consists, according to M. Vauquelin, of 47 sorbic acid, and 53 barytes in 100. Sorbate of lime well dried, appeared to be composed of 67 acid + 33 lime = 100. Sorbate of lead, which in solution, like most of the other sorbates, retains an acidulous taste, consists in the dried state of 33 acid + 67 oxide of lead in 100. The ordinary sorbate contains 12.5 per cent. of water. M. Vauquelin says that Mr. Donovan was mistaken in supposing that he had obtained super and subsorbates of lead. There is only one salt with this base, according to M. Vauquelin. It is nearly insoluble in cold water; but a little more so in boiling water: as it cools it crystallizes in the beautiful white, brilliant, and shining needles, of which we have already spoken. A remarkable phenomenon occurs, when sorbate of lead is boiled in water. Whilst one part of the salt saturates the water, the other part, for want of a sufficient quantity of fluid to dissolve it, is partially melted, and is at first kept on the surface by the force of ebullition, but after some time falls to the bottom, and as it cools becomes strongly fixed to the vessel.

To procure sorbic acid, M. Braconnot saturates with chalk the juice of the scarcely ripe berries, evaporates to the consistence of a syrup, removing the froth; and a granular sorbate falls, which he decomposes by carbonate of soda. The sorbate of soda is freed from colouring matter by a little lime, strained, freed from lime by carbonic acid gas, and decomposed by subacetate of lead, and treated as above.

M. Vauquelin analyzed the acid, in the dry sorbates of copper and lead.

The following are its constituents:

Hydrogen,	16.8
Carbon,	28.3
Oxygen,	54.9
	100.0

M. Vauquelin's analysis of the sorbate of lead gives 7.0 for the prime equivalent of this acid; the sorbate of lime gives 7.230; and the sorbate of barytes 8.6. If we take that of lime for the standard, as it was the only one quite neutral, we shall have the following relation of prime equivalents:

		Theory.	Experiment.
4 of oxygen	= 4.00	53.3	54.9
3 of carbon	= 2.25	30.0	28.3
10 of hydrogen	= 1.25	16.7	16.8
	7.50	100.0	100.0

The approximation of these sets of proportions illustrates and confirms the accuracy of M. Vauquelin's researches.

The calcareous salt having been procured in a neutral state, by the addition of carbonate of potash to its acidulous solution, it might readily be mixed with as much carbonate of lime as would diminish the apparent equivalent of acid from 7.50 to 7.230; especially as the barytic compound gives no less than 8.6. Had the composition of the sorbate of lime been 67.7 and 32.3, instead of 67 and 33, the prime equivalent of the acid would come out 7.5, as its ultimate analysis indicates.

As the pure sorbic acid appears to be without odour, without colour, and of an agreeable taste, it might be substituted for the tartaric and citric, in medicine and the arts.

The same acid may be got from apples, in a similar way.

ACID (STIBIC). See Acid (Antimonic).

ACID (STIBIOUS). See Acid (Antimonious).

ACID (SUBERIC). M. Chevreul obtained the suberic acid by mere digestion of the nitric acid on grated cork, without distillation, and purified it by washing with cold water. 12 parts of cork may be made to yield one of acid. When pure, it is white and pulverulent, having a feeble taste, and little action on litmus. It is soluble in 80 parts of water at 55½° F. and in 38 parts at 140°. It is much more soluble in alcohol, from which water throws down a portion of the suberic acid. It occasions a white precipitate when poured into acetate of lead, nitrates of lead, mercury, and silver, muriate of tin, and protosulphate of iron. It affords no precipitate with solutions of copper or zinc. The suberates of potash, soda, and ammonia, are very soluble. The two latter may be readily crystallized. Those of barytes, lime, magnesia, and alumina, are of sparing solubility.

ACID (SUCCINIC). It has long been known that amber, when exposed to distillation, affords a crystallized substance, which sublimes into the upper part of the vessel.

M. Julin, of Abo, states, that by mixing with coarsely powdered amber $\frac{1}{12}$ part of sulphuric acid, diluted with an equal weight of water, the succinic acid will be produced in about twice the quantity got in the old way.

Several processes have been proposed for purifying this acid: that of Richter appears to be the best. The acid being dissolved in hot water, and filtered, is to be saturated with potash or soda, and boiled with charcoal, which absorbs the oily matter. The solution being filtered, nitrate of lead is added; whence results an insoluble succinate of lead, from which, by digestion in the equivalent quantity of sulphuric acid, pure succinic acid is separated. Nitrate or muriate of barytes will show whether any sulphuric acid remains mixed with the succinic solution; and if so, it may be withdrawn by digesting the liquid with a little more succinate of lead. Pure succinic acid may be obtained by evaporation, in white transparent prismatic crystals. Their taste is somewhat sharp, and they redden powerfully tincture of turnsole. Heat melts and partially decomposes succinic acid. Air has no effect upon it. It is soluble in both water and alcohol, and much more so when they are heated. Its prime equivalent, by Berzelius, is 6.26; and it is composed of 4.51 hydrogen, 47.6 carbon, 47.888 oxygen, in 100, or 2 + 4 + 3 primes.

With barytes and lime the succinic acid forms salts but little soluble; and with magnesia it unites into a thick gummy substance. The succinates of potash and ammonia are crystallizable and deliquescent; that of soda does not attract moisture. The succinate of ammonia is useful in analysis to separate oxide of iron.

ACID (SULPHOVINIC). The name given by Vogel to an acid, or class of acids, which may be obtained by digesting alcohol and sulphuric acid together with heat.

ACID (SULPHURIC). Sulphuric acid was formerly obtained in this country by distillation from sulphate of iron, as it still is in many parts abroad. The fluid that is thus obtained is the German sulphuric acid, of which Bernhardt got sixty-four pounds from six hundred weight of vitriol; and on the other hand, when no water had been previously poured into the receiver, fifty-two pounds only of a dry concrete acid. This acid was formerly called *glacial oil of vitriol.*

It was shown by Vogel, that when this fuming acid is put into a glass retort, and distilled by a moderate heat into a receiver cooled with ice, the fuming portion comes over first, and may be obtained in a solid state by stopping the distillation in time. This constitutes absolute sulphuric acid, or acid entirely void of water. It is in silky filaments, tough, difficult to cut, and somewhat like asbestos. Exposed to the air, it fumes strongly, and gradually evaporates. It does not act on the skin so rapidly as concentrated oil of vitriol. Up to 66° it continues solid, but at temperatures above this it becomes a colourless vapour, which whitens on contact with air. Dropped into water in small quantities, it excites a hissing noise, as if it were red-hot iron; in larger quantities it produces a species of explosion. It is convertible into ordinary sulphuric acid, by the addition of water. It dissolves sulphur, and assumes a blue, green, or brown colour, according to the proportion of sulphur dissolved. The specific gravity of the black fuming sulphuric acid, prepared in large quantities from copperas, at Nordhausen, is 1.896.

The ordinary liquid acid of Nordhausen is brown, of variable density, and boils at 100° or 120° F. One part of it evaporates in dense fumes, and the remainder is found to be common oil of vitriol. The above solid anhydrous acid has a specific gravity of 1.97 at 68° F.; at 77.0 it remains fluid, and is less viscid than oil of vitriol. There is a little sulphurous acid present in that of Nordhausen, but it is accidental, and not essential to its constitution. The anhydrous acid makes a red solution of indigo. In the Journal of Science, xix. 62, I published the result of some experiments which I made to determine the nature of the solid acid. The brown liquid acid had a specific gravity of 1.842. When distilled from a retort into a globe surrounded with ice, a white solid sublimate was received. When this sublimate was exposed to the air, it emitted copious fumes of sulphuric (not sulphurous) acid. It burned holes in paper with the rapidity of a red hot iron. By dropping a bit of it into a poised phial containing water, and stoppering instantly, to prevent the ejection of liquid by the explosive ebullition that ensues, I got a dilute acid containing a known portion of the solid acid, from the specific gravity of which, as well as its saturating power, I determined the constitution of the solid acid to be the anhydrous sulphuric; or a compound of two by weight of sulphur and three of oxygen. M. Gmelin states in the Annales de Chimie et de Physique, for June 1826, that on distilling sulphuric acid, if we change the receiver at the instant when it is filled with opaque vapours, cover the new receiver with ice, we shall obtain anhydrous sulphuric acid, which is deposited in crystals on the inside of the vessel, and a less dense liquid acid which remains in the retort. He supposes that during the distillation, the sulphuric acid is divided into two portions, one of which gives up its water to the other.

The sulphuric acid made in Great Britain is produced by the combustion of sulphur. A mixture of nine parts of sulphur with one of nitre is placed in a proper vessel, enclosed within a chamber of considerable size, lined on all sides with lead, and covered at bottom with a shallow stratum of water. The mixture being set on fire will burn for a considerable time by virtue of the supply of oxygen which nitre gives out when heated, and the water imbibing the sulphurous vapours becomes gradually more and more acid after repeated combustions, and the acid is afterward concentrated.

Such was the account usually given of this operation, till MM. Clement and Desormes showed, in a very interesting memoir, its total inadequacy to account for the result. 100 parts of nitre, judiciously managed, will produce, with the requisite quantity of sulphur, 2000 parts of concentrated sulphuric acid. Now these contain 1200 parts of oxygen, while the hundred parts of nitre contain only 39⅓ of oxygen; being not $\frac{1}{30}$th part of what is afterwards found in the resulting sulphuric acid. But after the combustion of the sulphur, the nitre is converted into sulphate and bisulphate of potash, which mingled residuary salts contain nearly as much oxygen as the nitre originally did. Hence the origin of the 1200 parts of the oxygen in the sulphuric acid is still to be sought for. The following ingenious theory was first given by MM. Clement and Desormes. The burning sulphur or sulphurous acid, taking from the nitre a portion of its oxygen, forms sulphuric acid, which unites with the potash, and displaces a little nitrous and nitric acids in vapour. These vapours are decomposed by the sulphurous acid, into nitrous gas, or deutoxide of azote. This gas, naturally little denser than air, and now expanded by the heat, suddenly rises to the roof of the chamber; and might be expected to escape at the aperture there, which manufacturers were always obliged to leave open, otherwise they found the acidification would not proceed. But the instant that nitrous gas comes in contact with atmospherical oxygen, nitrous acid vapour is formed, which being a very heavy aeriform body, immediately precipitates on the sulphurous flame, and converts it into sulphuric acid; while itself resuming the state of nitrous gas, reascends for a new charge of oxygen, again to redescend, and transfer it to the flaming sulphur. Thus we see, that a small volume of nitrous vapour, by its alternate metamorphoses into the states of oxide and acid, and its consequent interchanges, may be capable of acidifying a great quantity of sulphur.

This beautiful theory received a modification from Sir H. Davy. He found that nitrous gas had no action on sulphurous gas, to convert it into sulphuric acid, unless water be present. With a *small* proportion of water, 4 volumes of sulphurous acid gas, and 3 of nitrous gas, are condensed into a crystalline solid, which is instantly decomposed by *abundance* of water: oil of vitriol is formed, and nitrous gas given off, which with contact of air becomes nitrous acid gas, as above described. The process continues, according to the same principle of combination and decomposition, till the water at the bottom of the chamber is become strongly acid. It is first concentrated in large leaden pans, and afterwards in glass retorts heated in a sand bath. Platinum alembics, placed within pots of cast-iron of a corresponding shape and capacity, have been lately substituted in many manufactories for glass, and have been found to save fuel, and quicken the process of concentration.

Dr. Henry describes a peculiar substance produced during very cold weather, in the leaden pipe, by which the foul air of a sulphuric acid chamber was carried away. It was a solid resembling borax. It became soft and pasty in a warm room, and gradually a thick liquid of sp. gr. 1.831 floated over the solid part. The crystalline part, Dr. Henry considers as probably the same compound as MM. Clement and Desormes obtained by mingling sulphurous acid, nitrous gas, atmospheric air, and aqueous vapour; and he thinks its constitution is probably

5 atoms sulphuric acid -	25.00
1 atom hyponitrous acid - -	4.75
5 atoms water - -	5.625
	35.375

Ann. of Phil. xi. 368.

The proper mode of burning the sulphur with the nitre, so as to produce the greatest quantity of oil of vitriol, is a problem, concerning which chemists hold a variety of opinions. M. Thenard describes the following as the best. Near one of the sides of the leaden chamber, and about a foot above its bottom, an iron plate, furnished with an upright border, is placed horizontally over a furnace, whose chimney passes across, under the bottom of the chamber, without having any connexion with it. On this plate, which is enclosed in a little chamber, the mixture of sulphur and nitre is laid. The whole being shut up, and the bottom of the large chamber covered with water, a gentle fire is kindled in the furnace. The sulphur soon takes fire, and gives birth to the products described. When the combustion is finished, which is seen through a little pane adapted to the trap-door of the chamber, this is opened, the sulphate of potash is withdrawn, and is replaced by a mixture of sulphur and nitre. The air in the great chamber is meanwhile renewed by opening its lateral door, and a valve in its opposite side. Then, after closing these openings, the furnace is lighted anew. Successive mixtures are thus burned till the acid acquires a specific gravity of about 1.390, taking care never to put at once on the plate more sulphur than the air of the chamber can acidify. The acid is then withdrawn by stopcocks, and concentrated.

The following details are extracted from a paper on sulphuric acid, which I published in the 4th volume of the Journal of Science and the Arts.

The best commercial sulphuric acid that I have been able to meet with contains from one-half to three quarters of a part in the hundred of solid saline matter, foreign to its nature. These fractional parts consist of sulphate of potash and lead, in the proportion of four of the former to one of the latter. It is, I believe, difficult to manufacture it directly by the usual methods, of a purer quality. The ordinary acid sold in the shops contains often three or four per cent. of saline matter. Even more is occasionally introduced, by the employment of nitre, to remove the brown colour given to the acid by carbonaceous matter. The amount of these adulterations, whether accidental or fraudulent, may be readily determined by evaporating in a small capsule of porcelain, or rather platinum, a definite weight of the acid. The platinum cup placed on the red cinders of a common fire will give an exact result in five minutes. If more than five grains of matter remain from five hundred of acid, we may pronounce it sophisticated.

Distillation is the mode by which pure oil of vitriol is obtained. This process is described in chemical treatises as both difficult and hazardous; but since adopting the following plan, I have found it perfectly safe and convenient. I take a plain glass retort, capable of holding from two to four quarts of water, and put into it about a pint measure of the sulphuric acid (and a few fragments of glass), connecting the retort with a large globular receiver, by means of a glass tube four feet long, and from one to two inches in diameter. The tube fits very loosely at both ends. The retort is placed over a charcoal fire, and the flame is made to play gently on its bottom. When the acid begins to boil smartly, sudden explosions of dense vapour rush forth from time to time, which would infallibly break small vessels. Here, however, these expansions are safely permitted, by the large capacity of the retort and receiver, as well as by the easy communication with the air at both ends of the adopter tube. Should the retort, indeed, be exposed to a great intensity of flame, the vapour will no doubt be generated with incoercible rapidity, and break the apparatus. But this accident can proceed only from gross imprudence. It resembles, in suddenness, the explosion of gunpowder, and illustrates admirably Dr. Black's observation, that, but for the great latent heat of steam, a mass of water, powerfully heated, would explode on reaching the boiling temperature. I have ascertained, that the specific caloric of the vapour of sulphuric acid is very small, and hence the danger to which rash operators may be exposed during its distillation. Hence, also, it is unnecessary to surround the receiver with cold water, as when alcohol and most other liquids are distilled. Indeed the application of cold to the bottom of the receiver generally causes it, in the present operation, to crack. By the above method, I have made the concentrated oil of vitriol flow over in a continuous slender stream, without the globe becoming sensibly hot.

I have frequently boiled the *distilled* acid till only one-half remained in the retort; yet at the temperature of 60° Fahrenheit, I have never found the specific gravity of acid so concentrated, to exceed 1.8455. It is, I believe, more exactly 1.8452. The number 1.850, which it has been the fashion to assign for the density of pure oil of vitriol, is undoubtedly very erroneous, and ought to be corrected. Genuine *commercial* acid should never surpass 1.8475; when it is denser, we may infer sophistication, or negligence, in the manufacture.

The progressive increase of its density, with saline contamination, will be shown by the following experiments:—To 4100 grains of genuine commercial acid (but concentrated to only 1.8350) 40 grains of dry sulphate of potash were added. When the solution was completed, the specific gravity at 60° had become 1.8417. We see that at these densities the addition of 0.01 of salt increases the specific gravity by about 0.0067. To the above 4140 grains other 80 grains of sulphate were added, and the specific gravity, after solution, was found to be 1.8526. We perceive that somewhat more salt is now required to produce a proportional increase of density; 0.01 of the former changing the latter by only 0.0055. Five hundred grains of this acid being evaporated in a platinum capsule left $16\frac{1}{2}$ grains, whence the composition was

Sulphate of potash, with a little sulphate of lead, - - -	3.30
Water of dilution, - -	5.3
Oil of vitriol of 1.8485, -	91.4
	100.0

Thus, acid of 1.8526, which in commerce would have been accounted very strong, contained little more than 91 per cent. of genuine acid.

Into the last acid more sulphate of potash was introduced, and solution being favoured by digestion in a moderate heat, the specific gravity became, at 60°, 1.9120. Of this compound, 300 grains, evaporated in the platinum capsule, left 41 grains of gently ignited saline matter. We have, therefore, nearly 14 per cent. On the specific gravity in this interval, an increase of 0.0054 was effected by 0.01 of sulphate. This liquid was composed of saline

matter, - - - - -	14.
Water of dilution, - - -	4.7
Oil of vitriol of 1.8485, - -	81.3
	100.0

The general proportion between the density and impurity may be stated at 0.0055 of the former, to 0 01 of the latter.

If from genuine oil of vitriol, containing $\frac{3}{4}$ of a per cent. of saline matter, a considerable quantity of acid be distilled off, what remains in the retort will be found very dense. At the specific gravity 1.865, such acid contains $3\frac{1}{2}$ of solid salt in the 100 parts. The rest is pure concentrated acid. From such heavy acid, at the end of a few days, some minute crystals will be deposited, after which its specific gravity becomes 1.860, and its transparency is perfect. It contains about $2\frac{1}{4}$ per cent. of saline matter. Hence if the chemist employ for his researches an acid, which, though originally pretty genuine, has been exposed to long ebullition, he will fall into great errors. From the last experiments it appears, that *concentrated* oil of vitriol can take up only a little saline matter in comparison with that which is somewhat dilute. It is also evident, that those who trust to specific gravity alone, for ascertaining the value of oil of vitriol, are liable to great impositions.

The saline impregnation exercises an important influence on all the densities at subsequent degrees of dilution. Thus, the heavy impure *concentrated* acid, specific gravity 1.8650, being added to water in the proportion of one part to ten, by weight gave, after twenty-four hours, a compound whose specific gravity was 1.064. But the most concentrated genuine acid, as well as distilled acid, by the same degree of dilution, namely 1 + 10, acquires the specific gravity of only 1.0602, while that of 1.852, containing, as stated above, 3½ per cent. of sulphate of potash combined with acid of 1.835, gives, on a similar dilution, 1.058. This difference, though very obvious to good instruments, is inappreciable by ordinary commercial apparatus. Hence this mode of ascertaining the value of an acid, recommended by Mr. Dalton, is inadequate to detect a deterioration of even 8 or 9 per cent. Had a little more salt been present in the acid, the specific gravity of the dilute, in this case, would have equalled that of the genuine. On my acidemeter one per cent. of deterioration could not fail to be detected, even by those ignorant of science.

The quantity of oxide, or rather sulphate of lead, which sulphuric acid can take up, is much more limited than is commonly imagined. To the concentrated oil of vitriol I added much carbonate of lead, and after digestion by a gentle heat, in a close vessel, for twenty-four hours, with occasional agitation, its specific gravity, when taken at 60°, was scarcely greater than before the experiment. It contained about 0.005 of sulphate of lead.

The quantity of water present in 100 parts of concentrated and pure oil of vitriol, seems to be pretty exactly 18.46.

In the experiments executed to determine the relation between the density of diluted oil of vitriol, and its acid strength, I employed a series of phials, numbered with a diamond. Into each phial, recently boiled acid, and pure water, were mixed in the successive proportions of 99 + 1; 98 + 2; 97 + 3, &c. through the whole range of digits down to 1 acid + 99 water. The phials were occasionally agitated during 24 hours, after which the specific gravity was taken. The acid was genuine and well concentrated. Its specific gravity was 1.8485. Some of the phials were kept with their acid contents for a week or two, but no further change in the density took place. The strongest possible *distilled* acid was employed for a few points, and gave the same results as the other.

Of the three well-known modes of ascertaining the specific gravity of a liquid, namely, that by Fahrenheit's hydrometer; by weighing a vessel of known capacity filled with it; and by poising a glass ball, suspended by a fine platina wire from the arm of a delicate balance —I decidedly prefer the last. The corrosiveness, viscidity, and weight of oil of vitriol, render the first two methods ineligible; whereas, by a ball floating in a liquid, of which the specific gravity does not differ much from its own, the balance, little loaded, retains its whole sensibility, and will give the most accurate consistency of results.

In taking the specific gravity of concentrated or slightly diluted acid, the temperature must be minutely regulated, because, from the small specific heat of the acid, it is easily affected, and because it greatly influences the density. On removing the thermometer, it will speedily rise in the air to 75° or 80°, though the temperature of the apartment be only 60°. Afterwards it will slowly fall to perhaps 60° or 62°. If this thermometer, having its bulb covered with a film of dilute acid, (from absorption of atmospheric moisture) be plunged into a strong acid, it will instantly rise 10°, or more, above the real temperature of the liquid. This source of embarrassment and occasional error is obviated by wiping the bulb after every immersion. An elevation of temperature, equal to 10° Fahr. diminishes the density of oil of vitriol by 0.005; 1000 parts being heated from 60° to 212°, become 1.043 in volume, as I ascertained by very careful experiments. The specific gravity, which was 1,848, becomes only 1.772, being the number corresponding to a dilution of 14 per cent. of water. The viscidity of oil of vitriol, which below 50° is such as to render it difficult to determine the specific gravity by a floating ball, diminishes very rapidly as the temperature rises, evincing that it is a modification of cohesive attraction.

The following table of densities, corresponding to degrees of dilution, was the result, in each point, of a particular experiment, and was, moreover, verified in a number of its terms, by the further dilution of an acid, previously combined with a known proportion of water. The balance was accurate and sensible.

TABLE of the quantity of Oil of Vitriol and Dry Sulphuric Acid in 100 *parts of Dilute, at different Densities, by* DR. URE.

Liquid.	Sp. Gr.	Dry.	Liquid.	Sp. Gr.	Dry.	Liquid.	Sp. Gr.	Dry.
100	1.8485	81.54	66	1.5503	53.82	32	1.2334	26.09
99	1.8475	80.72	65	1.5390	53.00	31	1.2260	25.28
98	1.8460	79.90	64	1.5280	52.18	30	1.2184	24.46
97	1.8439	79.09	63	1.5170	51.37	29	1.2108	23.65
96	1.8410	78.28	62	1.5066	50.55	28	1.2032	22.83
95	1.8376	77.46	61	1.4960	49.74	27	1.1956	22.01
94	1.8336	76.65	60	1.4860	48.92	26	1.1876	21.20
93	1.8290	75.83	59	1.4760	48.11	25	1.1792	20.38
92	1.8233	75.02	58	1.4660	47.29	24	1.1706	19.57
91	1.8179	74.20	57	1.4560	46.48	23	1.1626	18.75
90	1.8115	73.39	56	1.4460	45.66	22	1.1549	17.94
89	1.8043	72.57	55	1.4360	44.85	21	1.1480	17.12
88	1.7962	71.75	54	1.4265	44.03	20	1.1410	16.31
87	1.7870	70.94	53	1.4170	43.22	19	1.1330	15.49
86	1.7774	70.12	52	1.4073	42.40	18	1.1246	14.68
85	1.7673	69.31	51	1.3977	41.58	17	1.1165	13.86
84	1.7570	68.49	50	1.3884	40.77	16	1.1090	13.05
83	1.7465	67.68	49	1.3788	39.95	15	1.1019	12.23
82	1.7360	66.86	48	1.3697	39.14	14	1.0953	10.41
81	1.7245	66.05	47	1.3612	38.32	13	1.0887	11.60
80	1.7120	65.23	46	1.3530	37.51	12	1.0809	9.78
79	1.6993	64.42	45	1.3440	36.69	11	1.0743	8.97
78	1.6870	63.60	44	1.3345	35.88	10	1.0682	8.15
77	1.6750	62.78	43	1.3255	35.06	9	1.0614	7.34
76	1.6630	61.97	42	1.3165	34.25	8	1.0544	6.52
75	1.6520	61.15	41	1.3080	33.43	7	1.0477	5.71
74	1.6415	60.34	40	1.2999	32.61	6	1.0405	4.89
73	1.6321	59.52	39	1.2913	31.80	5	1.0336	4.08
72	1.6204	58.71	38	1.2826	30.98	4	1.0268	3.26
71	1.6090	57.89	37	1.2740	30.17	3	1.0206	2.446
70	1 5975	57.08	36	1.2654	29.35	2	1.0140	1.63
69	1.5868	56.26	35	1.2572	28.54	1	1.0074	0.8154
68	1.5760	55.45	34	1.2490	27.72			
67	1.5648	54.63	33	1.2409	26.91			

In order to compare the densities of the preceding dilute acid, with those of distilled and again concentrated acid, I mixed one part of the latter with nine of pure water, and after agitation, and a proper interval, to ensure thorough combination, I found its specific gravity as above, 1.0682: greater density indicates saline contamination.

Dilute acid having a specific gravity = 1.6321, has suffered the greatest condensation; 100 parts in bulk have become 92.14. If either more or less acid exist in the compound, the volume will be increased. What reason can be assigned for the maximum condensation occurring at this particular term of dilution? The above dilute acid consists of 73 per cent. of oil of vitriol, and 27 of water. But 73 of the former contains, by this Table, 59.52 of dry acid, and 13.48 of water. Hence 100 of the dilute acid consist of 59.52 of dry acid, + 13.48 × 3 = 40.44 of water = 99.96; or it is a compound of one atom of dry acid, with three atoms of water. Dry sulphuric acid consists of three atoms of oxygen, united to one of sulphur. Here each atom of oxygen is associated with one of water, forming a symmetrical arrangement. We may therefore infer, that the least deviation from the above definite proportions must impair the balance of the attractive forces, whence they will act less efficaciously, and therefore produce less condensation.

The very minute and patient examination which I was induced to bestow on the table of specific gravities, disclosed to me the general law pervading the whole, and consequently the means of inferring at once the density from the degree of dilution, as also of solving the inverse proposition.

If we take the specific gravity, corresponding to ten per cent. of oil of vitriol, or 1.0682 as the root; then the specific gravities at the successive terms of 20, 30, 40, &c. will be the successive powers of that root. The terms of dilution are like logarithms, a series of numbers in arithmetical progression, corresponding to another series, namely, the specific gravities in geometrical progression.

The simplest logarithmic formula which I have been able to contrive is the following.

Log. $S = \frac{2a}{700}$, where S is the specific gravity, and a the per centage of acid.

And $a = \text{Log. } S \times 350$.

In common language the two rules may be stated thus.

Problem 1st, To find the proportion of oil of vitriol in dilute acid of a given specific gravity. Multiply the logarithm of the specific gravity by 350, the product is directly the per centage of acid.

If the dry acid be sought, we must multiply the logarithm of the specific gravity by 285, and the product will be the answer.

Problem 2d, To find the specific gravity corresponding to a given proportion of acid. Multiply the quantity of acid by 2, and divide by 700; the quotient is the logarithm of the specific gravity.

Table of distilled sulphuric acid for the higher points, below which it agrees with the former table.

Liquid Acid in 100.	Sp. Gr.	Dry Acid.
100	1.846	81.63
95	1.834	77.55
90	1.807	73.47
85	1.764	69.39
80	1.708	65.30
75	1.650	61.22

Sulphuric acid strongly attracts water, which it takes from the atmosphere very rapidly, and in larger quantities, if suffered to remain in an open vessel, imbibing one-third of its weight in twenty-four hours, and more than six times its weight in a twelvemonth. If four parts by weight be mixed with one of water at 50°, they produce an instantaneous heat of 300° F.; and four parts raise one of ice to 212°: on the contrary, four parts of ice, mixed with one of acid, sink the thermometer to 4° below 0. It requires a great degree of cold to freeze it; and if diluted with half a part or more of water, unless the dilution be carried very far, it becomes more and more difficult to congeal; yet at the specific gravity of 1.78, or a few hundredths above or below this, it may be frozen by surrounding it with melting snow. Its congelation forms regular prismatic crystals with six sides. Its boiling point, according to Bergman, is 540°; according to Dalton, 590°.

Sulphuric acid consists of three prime equivalents of oxygen, one of sulphur, and one of water; and by weight, therefore, of 3.0 oxygen + 2.0 sulphur + 1.125 water = 6.125, which represents the prime equivalent of the concentrated liquid acid; while 3 + 2 = 5, will be that of the dry acid.

Pure sulphuric acid is without smell and colour, and of an oily consistence. Its action on litmus is so strong, that a single drop of acid will give to an immense quantity of water the power of reddening. It is a most violent caustic; and has sometimes been administered with the most criminal purposes. The person who unfortunately swallows it, speedily dies in dreadful agonies and convulsions Chalk, or common carbonate of magnesia, is the best antidote for this, as well as for the strong nitric and muriatic acids.

When transmitted through an ignited porcelain tube of one-fifth of an inch diameter, it is resolved into two parts of sulphurous acid gas, and one of oxygen gas, with water. Voltaic electricity causes an evolution of sulphur at the negative pole; whilst a sulphate of the metallic wire is formed at the positive. Sulphuric acid has no action on oxygen gas or air. It merely abstracts their aqueous vapour.

If the oxygenized muriatic acid of M. Thenard be put in contact with the sulphate of silver, there is immediately formed insoluble chloride of silver, and oxygenized sulphuric acid. To obtain sulphuric acid in the highest degree of oxygenation, it is merely necessary to pour barytes water into the above oxygenized acid, so as to precipitate only a part of it, leaving the rest in union with the whole of the oxygen. Oxygenized sulphuric acid partially reduces the oxide of silver, occasioning a strong effervescence. See Acid.

All the simple combustibles decompose sulphuric acid, with the assistance of heat. About 400° Fahr. sulphur converts sulphuric into sulphurous acid. Several metals at an elevated temperature decompose this acid, with evolution of sulphurous acid gas, oxidizement of the metal, and combination of the oxide with the undecomposed portion of the acid.

Sulphuric acid is of very extensive use in the art of chemistry, as well as in metallurgy, bleaching, and some of the processes for dyeing; in medicine it is given as a tonic and stimulant, and is sometimes used externally as a caustic.

The combinations of this acid with the various bases are called sulphates, and most of them have long been known by various names. With barytes it is found native and nearly pure in various forms. See Heavy Spar. It may be artificially formed by dropping a solution of an alkaline sulphate into the solution of muriate or nitrate of barytes. It forms a white powder which suffers no change by the action of the air, and is therefore sometimes used in water-colour painting.

It consists, according to Dr. Wollaston, of 5 parts of dry acid, and 9.75 of barytes. It requires 43,000 parts of water to dissolve it at 60°.

Sulphate of strontian has a considerable resemblance to that of barytes in its properties.

It is found native in considerable quantities at Aust Passage and other places in the neighbourhood of Bristol. It requires 3840 parts of boiling water to dissolve it.

Its composition is 5 acid + 6.5 base.

The sulphate of potash, formerly *vitriolated tartar*, crystallizes in hexaëdral prisms, terminated by hexagonal pyramids, but susceptible of variations. Its crystallization by quick cooling is confused. Its taste is bitter, acrid, and a little saline. It is soluble in 5 parts of boiling water, and 16 parts at 60°. In the fire it decrepitates, and is fusible by a strong heat. It is decomposable by charcoal at a high temperature. It may be prepared by direct mixture of its component parts; but the usual and cheapest mode is to ignite the acidulous sulphate left after distilling nitric acid. The *sal polychrest* of old dispensatories, made by deflagrating sulphur and nitre in a crucible, was a compound of the sulphate and sulphite of potash. The acidulous sulphate is sometimes employed as a flux, and likewise in the manufacture of alum. In medicine the neutral salt is sometimes used as a mild cathartic.

It consists of 5 acid + 6 base; but there is a compound of the same constituents, in the proportion of 10 acid + 6 potash, called the bi-sulphate.

The sulphate of soda is the well known *Glauber's salt*. It is commonly prepared from the residuum left after distilling muriatic acid, the superfluous acid of which may be expelled by ignition; and is likewise obtained in the manufacture of the muriate of ammonia. (See Ammonia.) It exists in large quantities under the surface of the earth in some countries, as Persia, Bohemia, and Switzerland; is found mixed with other substances in mineral springs and sea water; and sometimes efflorces on walls. Sulphate of soda is bitter and saline to the taste. It is soluble in 2.85 parts of cold water, and 0.8 at a boiling heat; it crystallizes in hexagonal prisms bevelled at the extremities, sometimes grooved longitudinally, and of very large size, when the quantity is great: these effloresce completely into a white powder if exposed to a dry air, or even if kept wrapped up in paper in a dry place; yet they retain sufficient water of crystallization to undergo the aqueous fusion on exposure to heat, but by urging the fire, melt. Barytes and strontian take its acid from it entirely, and potash partially; the nitric and muriatic acids, though they have a weaker affinity for its base, combine with a part of it when digested on it. Heated with charcoal its acid is decomposed. As a purgative its use is very general; and it has been employed to furnish soda. Pajot des Charmes has made some experiments on it in fabricating glass; with sand alone it would not succeed, but equal parts of carbonate of lime, sand, and dried sulphate of soda, produced a clear, solid, pale yellow glass.

It is composed of 5 acid + 4 base + 11.25 water in crystals; when dry, the former two primes are its constituents.

Sulphate of soda and sulphate of ammonia form together a triple salt.

Sulphate of lime, *selenite*, *gypsum*, *plaster of Paris*, or sometimes *alabaster*, form extensive strata in various mountains. (See Gypsum.)

It requires 500 parts of cold water, and 450 of hot, to dissolve it. When calcined, it decrepitates, becomes very friable and white, and heats a little with water, with which it forms a solid mass. In this process it loses its water of crystallization. The calcined sulphate is much employed for making casts of anatomical and ornamental figures; as one of the bases of stucco; as a fine cement for making close and strong joints between stone, and joining rims or tops of metal to glass; for making moulds for the Staffordshire potteries; for cornices, mouldings, and other ornaments in building. For these purposes, and for being wrought into columns, chimney-pieces, and various ornaments, about eight hundred tons are raised annually in Derbyshire, where it is called alabaster. In America it is laid on grass land as a manure.

Ordinary crystallized gypsum consists of 5 sulphuric acid + 3.5 lime + 2.25 water; the anhydrous variety wants of course the last ingredient.

Sulphate of magnesia is commonly known by the name of *Epsom salt*, as it was furnished in considerable quantity by the mineral water at that place, mixed, however, with a considerable portion of sulphate of soda. It is afforded, however, in greater abundance and more pure from the bittern left after the extraction of salt from sea water. It has likewise been found efflorescing on brick walls, both old and recently erected, and in small quantity in the ashes of coals. The capillary salt of Idria, found in silvery crystals mixed with the aluminous schist in the mines of that place, and hitherto considered as a feathery alum, has been ascertained by Klaproth to consist of sulphate of magnesia, mixed with a small portion of sulphate of iron. When pure it crystallizes in small quadrangular prisms, terminated by quadrangular pyramids or diëdral summits. Its taste is cool and bitter. It is very soluble, requiring only an equal weight of cold water, and three-fourths its weight of hot. It effloresces in the air, though but slowly. If it attract moisture, it contains muriate of magnesia or of lime. Exposed to heat, it dissolves in its own water of crystallization, and dries, but is not decomposed, nor fused, but with extreme difficulty. It consists, according to Bergman, of 33 acid, 19 magnesia, 48 water. A very pure sulphate is said to be prepared in the neighbourhood of Genoa, by roasting a pyrites found there; exposing it to the air in a covered place for six months, watering it occasionally, and then lixiviating.

Sulphate of magnesia is one of our most valuable purgatives; for which purpose only it is used, and for furnishing the carbonate of magnesia.

It is composed of 5 acid + 2.5 magnesia + 7.875 water, in the state of crystals.

Sulphate of ammonia crystallizes in slender, flattened, hexaëdral prisms, terminated by hexagonal pyramids; it attracts a little moisture from very damp air, particularly if the acid be in excess; it dissolves in two parts of cold and one of boiling water. It is not used, though Glauber, who called it his *secret ammoniacal salt*, vaunted its excellence in assaying.

It consists of 5 acid + 2.125 ammonia + 1.125 water in its most desiccated state; and in its crystalline state of 5 acid + 2.125 ammonia + 3.375 water.

If sulphate of ammonia and sulphate of magnesia be added together in solution, they combine into a triple salt of an octaëdral figure, but varying much; less soluble than either of its component parts; unalterable in the air; undergoing on the fire the watery fusion; after which it is decomposed, part of the ammonia flying off, and the remainder subliming with an excess of acid. It contains, according to Fourcroy, 68 sulphate of magnesia, and 32 sulphate of ammonia.

Sulphate of glucina crystallizes with difficulty, its solution readily acquiring and retaining a syrupy consistence; its taste is sweet, and slightly astringent; it is not alterable in the air; a strong heat expels its acid, and leaves the earth pure; heated with charcoal it forms a sulphuret; infusion of galls forms a yellowish-white precipitate with its solution.

Yttria is readily dissolved by sulphuric acid; and as the solution goes on, the sulphate crystallizes in small brilliant grains, which have a sweetish taste, but less so than sulphate of glucina, and are of a light amethyst-red colour. They require 30 parts of cold water to dissolve them, and give up their acid when exposed to a high temperature. They are decomposed by oxalic acid, prussiate of potash, infusion of galls, and phosphate of soda.

Sulphate of alumina in its pure state is but recently known, and it was first attentively examined by Vauquelin. It may be made by dissolving pure alumina in pure sulphuric acid, heating them for some time, evaporating the solution to dryness, drying the residuum with a pretty strong heat, redissolving it, and crystallizing. Its crystals are soft, foliaceous, shining, and pearly; but these are not easily obtained without cautious evaporation and refrigeration. They have an astringent taste; are little alterable in the air; are pretty soluble, particularly in hot water; give out their acid on exposure to a high temperature; are decomposable by combustible substances, though not readily; and do not form a pyrophorus like alum.

If the evaporation and desiccation directed above be omitted, the alumina will remain supersaturated with acid, as may be known by its taste, and by its reddening vegetable blue. This is still more difficult to crystallize than the neutral salt, and frequently thickens into a gelatinous mass.

A compound of acidulous sulphate of alumina with potash or ammonia has long been known by the name of ALUM. See ALUMINA.

If this acidulous sulphate or alum be dissolved in water, and boiled with pure alumina, the alumina will become saturated with its base, and fall down an insipid white powder. This salt is completely insoluble, and is not deprived of its acid by heat but at a very high temperature. It may be decomposed by long boiling with the alkaline or earth bases; and several acids convert it into common alum, but slowly.

Sulphate of zircon may be prepared by adding sulphuric acid to the earth recently precipitated, and not yet dry. It is sometimes in small needles, but commonly pulverulent; very friable; insipid; insoluble in water, unless it contain some acid; and easily decomposed by heat.

ACID (SULPHUROUS). This acid is formed by the ordinary combustion of sulphur in the open air: but it can be obtained most purely and conveniently by digesting mercury in sulphuric acid, with heat, in a retort. The metal becomes oxidized, and sulphurous acid gas is disengaged with effervescence. M. Berthier has recently shown that sulphurous acid gas may be obtained very pure and abundantly, by heating a mixture of twelve or fourteen parts of sublimed sulphur and a hundred parts of peroxide of manganese in a glass retort. The residue in the retort is not a sulphuret of manganese, but a protoxide of that metal, mixed with a little sulphate, and sometimes a little sulphur.—*Ann. de Chim. et de Phys.* xxiv. 275.

The gas may be collected over quicksilver, or received into water, which at the temperature of 61° will absorb 33 times its bulk, or nearly an eleventh of its weight.

Water thus saturated is intensely acid to the taste, and has the smell of sulphur burning slowly. It destroys most vegetable colours, but the blues are reddened by it previous to their being discharged. A pleasing instance of its effect on colours may be exhibited by holding a red rose over the blue flame of a common match, by which the colour will be discharged wherever the sulphurous acid comes into contact with it, so as to render it beautifully variegated, or entirely white. If it be then dipped into water, the redness after a time will be restored.

The specific gravity of sulphurous acid gas, as given by MM. Thenard and Gay Lussac, is 2·2553, but by Sir H. Davy is 2.2295, and hence 100 cubic inches weigh 68 grains; but its spr. gr. most probably should be estimated at 2.222, and the weight of 100 cubic inches will become 67.777. Its constituents by volume are one of oxygen, and one of vapour of sulphur; each having a sp. gr. of 1.111, condensed so that both volumes occupy only one. Or in popular language, sulphurous acid may be said to be a solution of sulphur in oxygen, which doubles the weight of this gas, without augmenting its bulk. It obviously, therefore, consists by weight of equal quantities of the two constituents. Its equivalent will either be 2 oxygen + 2 sulphur = 4.0; or 1 oxygen + 1 sulphur = 2. Now the analysis of sulphite of barytes by Berzelius gives 209·22 base to 86.53 acid; which being reduced, presents for the prime equivalent of sulphurous acid, the number 4. Hydrogen and carbon readily decompose sulphurous acid at a red heat, and even under it. Mr. Higgins discovered, that liquid sulphurous acid dissolves iron, without the evolution of any gas. The peroxides of lead and manganese furnish oxygen to convert it into sulphuric acid, which forms a sulphate, with the resulting metallic protoxide.

Sulphurous acid is used in bleaching, particularly for silks. It likewise discharges vegetable stains and iron-moulds from linen.

In combination with the salifiable bases, it forms sulphites which differ from the sulphates in their properties. The alkaline sulphites are more soluble than the sulphates, the earthy less. They are converted into sulphates by an addition of oxygen, which they acquire even by exposure to the air. The sulphite of lime is the slowest to undergo this change. A strong heat either expels their acid entirely, or converts them into sulphates. They have all a sharp, disagreeable, sulphurous taste. The best mode of obtaining them is by receiving the sulphurous acid gas into water, holding the base, or its carbonate, in solution, or diffused in it in fine powder. None of them has yet been applied to any use.

By putting sulphuric acid and mercury into the sealed end of a glass tube recurved, then sealing the other end, and applying heat to the former, Mr. Faraday obtained a liquid sulphurous acid.—(*Ph. Tr.* 1823.) Mr. Bussy (*Ann. de Chim. for May*, 1824) says that he liquefied the same gas, by transmitting it through fused chloride of calcium into a flask surrounded with a mixture of ice and salt. It remains in a liquid state in the air at the temperature of 0° F. It is a colourless transparent, and very volatile liquid, of a specific gravity = 1.45. It boils at 14° F. but in consequence of the cold produced by the evaporation of the portion that flies off, the residue remains liquid. It causes a feeling of intense cold when dropped on the hand. By evaporation of the acid *in vacuo*, M. Bussy froze alcohol, sp. gr. 0.850.

ACID (HYPOSULPHUROUS). In the 85th volume of the Annales de Chimie, M. Gay Lussac describes permanent crystallizable salts having lime and strontites for their base, combined with an acid of sulphur, in which the proportion of oxygen is less than in sulphurous acid; but this acid he does not seem to have examined in a separate state. Those salts were procured by exposing solutions of the sulphurets of the earths to the air, when sulphur and carbonate of lime precipitated. When the filtered liquid is then evaporated, and cooled, colourless crystals form. The calcareous are prismatic needles, and those with strontites are rhomboidal. He called these new compounds sulphuretted sulphites. Those of potash and soda he also formed, by heating their sulphites with sulphur; when a quantity of sulphurous acid was disengaged, and neutral salts were formed. M. Gay Lussac farther informs us, that boiling a solution of a sulphite with sulphur, determines the formation of the sulphuretted sulphite, or hyposulphite; and that iron, zinc, and manganese, treated with liquid sulphurous acid, yield sulphuretted sulphites; from which it follows, that a portion of the sulphurous acid is decomposed by the metal, and that the resulting oxide combines with the other portion of the sulphurous acid and the liberated sulphur. The hyposulphites are more permanent than the sulphites; they do not readily pass by the action of the air into the state of sulphate; and though decomposable at a high heat, they resist the action of fire longer than the sulphites. They are decomposed in solution by the sulphuric, muriatic, fluoric, phosphoric, and arsenic acids; sulphurous acid is evolved, sulphur is precipitated, and a *new* salt is formed. Such is the account given of these by M. Gay Lussac, and copied into the second volume of the Traité de Chimie of M. Thenard, published in 1814.

No additional information was communicated to the world on this subject till January 1819, when an ingenious paper on the hyposulphites appeared in the Edinburgh Philosophical Journal, followed soon by two others in the same periodical work, by Mr. Herschel.

In order to obtain hyposulphurous acid, Mr. Herschel mixed a dilute solution of hyposulphite of strontites with a slight excess of dilute sulphuric acid, and after agitation poured the mixture on three filters. The first was received into a solution of carbonate of potash, from which it expelled carbonic acid gas. The second portion being received successively into nitrates of silver and mercury, precipitated the metals copiously in the state of sulphurets, but produced no effect on solutions of copper, iron, or zinc. The third, being tasted, was acid, astringent, and bitter. When fresh filtered, it was clear; but it became milky on standing, depositing sulphur, and colouring sulphurous acid. A moderate exposure to air, or a gentle heat, caused its entire decomposition.

The habitudes of oxide of silver in union with this acid, are very peculiar. Hyposulphite of soda being poured on newly precipitated oxide of silver, hyposulphite of silver was formed, and caustic soda eliminated; the only instance, says Mr. Herschel, yet known, of the direct displacement of a fixed alkali by a metallic oxide, *via humida.* On the other hand, hyposulphurous acid newly disengaged from the hyposulphite of barytes, by dilute sulphuric acid, readily dissolved, and decomposed muriate of silver, forming a sweet solution, from which alcohol separated the metal in the state of hyposulphite. "Thus the affinity between this acid and base, *unassisted by any double decomposition*, is such as to form an exception to all the ordinary rules of chemical union." This acid has a remarkable tendency to form double salts with the oxides of silver and alkaline bases. The hyposulphite of silver and soda has an intensely sweet taste. When hyposulphite of ammonia is poured on muriate of silver, it dissolves it; and if into the saturated solution alcohol be poured, a white salt is precipitated, which must be forcibly squeezed between blotting paper, and dried *in vacuo.* It is very soluble in water. Its sweetness is unmixed with any other flavour, and so intense as to cause pain in the throat. One grain of the salt communicates a perceptible sweetness to 32,000 grains of water. If the alcoholic liquid be evaporated, thin lengthened hexangular plates are sometimes formed, which are not altered by keeping, and consist of the same principles.

The best way of obtaining the alkaline hyposulphites, is to pass a current of sulphurous acid gas through a *lixivium*, formed by boiling a watery solution of alkali, or alkaline earth, along with sulphur. The whole of the sulphurous acid is converted into the hyposulphite, and pure sulphur, unmixed with any sulphite, is precipitated, while the hyposulphite remains in solution.

Mr. Herschel, from his experiments on the hyposulphite of lime, has deduced the prime equivalent of hyposulphurous acid to be 59.25. He found that 100 parts of crystallized hyposulphite of lime were equivalent to 121.77 hyposulphite of lead, and yielded of carbonate of lime, by carbonate of ammonia, a quantity equivalent to 21.75 gr. of lime. Therefore the theory of equivalent ratios gives us this rule:—

As 21.75 gr. lime are to its prime equivalent 3.5, so are 121.77 gr. of hyposulphite of lead, to *its* prime equivalent. In numbers 21.75 : 3.5 : : 121.77 : 19.6. From this number, if we deduct the prime of the oxide of lead = 14, the remainder 5.6 will be the double prime of hyposulphurous acid. Now this number does not materially differ from 6. Hence we see that the hyposulphites, for their neutral condition, require of this feeble acid 2 prime proportions. One prime proportion of it is obviously made up of 1 prime of sulphur = 2, + 1 oxygen = 1; and the acid equivalent is = 3. The crystallized hyposulphite of lime is composed of 6. acid + 3.5 lime + 6.75 water, being 6 primes of the last constituent.

It ought to be stated, that when a solution of a hyposulphite is boiled down to a certain degree of concentration, it begins to be rapidly decomposed, with the deposition of sulphur and sulphite of lime. To obtain the salt in crystals, the solution must be evaporated at a temperature not exceeding 140° Fahr. If it be then filtered while hot, it will yield, on cooling, large and exceedingly beautiful crystals, which assume a great variety of complicated forms. They are soluble in nearly their own weight of water at 37° Fahr. and the temperature of the solution falls to 31°. The specific gravity of their saturated solution at 60° is 1.300; and when it is 1.114, the liquid contains one-fifth of its weight. The crystals are permanent in the air.

Hyposulphites of potash and soda yield deliquescent crystals of a bitter taste, and both of them dissolve muriate of silver. The ammoniacal salt is not easily procured in regular crystals. Its taste is pungent and disagreeable. The barytic hyposulphite is insoluble; the strontitic is soluble and crystallizable. Like the other hyposulphites, it dissolves silver; and while its own taste is purely bitter, it produces a sweet compound with muriate of silver, which alcohol throws down in a syrupy form. Hyposulphite of magnesia is a bitter tasted, soluble, crystallizable, and non-deliquescent salt. All the hyposulphites burn with a sulphurous flame. The sweetness of liquid hyposulphite of soda, combined with muriate of silver, surpasses honey in intensity, diffusing itself over the whole mouth and fauces without any disagreeable or metallic flavour. A coil of zinc wire speedily separates the silver in a metallic state, thus affording a ready analysis of muriate of silver. Muriate of lead is also soluble in the hyposulphites, but less readily.

ACID (HYPOSULPHURIC). MM. Gay Lussac and Welther have recently announced the discovery of a new acid combination of sulphur and oxygen, intermediate between sulphurous and sulphuric acids, to which they have given the name of hyposulphuric acid. It is obtained by passing a current of sulphurous acid gas over the black oxide of manganese. A combination takes place; the excess of the oxide of manganese is separated by dissolving the hyposulphate of manganese in water. Caustic barytes precipitates the manganese, and forms with the new acid a very soluble salt, which, freed from excess of barytes by a current of carbonic acid, crystallizes regularly, like the nitrate or muriate of barytes. Hyposulphate of barytes being thus obtained, sulphuric acid is cautiously added to the solution, which throws down the barytes, and leaves the hyposulphuric acid in the water. This acid bears considerable concentration under the receiver of the air-pump. It consists of five parts of oxygen to four of sulphur. The greater number of the hyposulphates, both earthy and metallic, are soluble, and crystallize; those of barytes and lime are unalterable in the air. Suberic acid and chlorine do not decompose the barytic salt. The barytic salt in crystals consists of barytes 9.75 + hyposulphuric acid 9.00 + water 2.25 = 20.95.

The following table exhibits the composition of the different acid compounds of sulphur and oxygen:—

Hyposulphurous acid,	20 sul.	+ 10 oxygen
Sulphurous acid,	10	+ 10
Hyposulphuric acid,	8	+ 10
Sulphuric acid,	6⅔	+ 10

Or if we prefer to consider the quantity of sulphur in each acid as = 2, the oxygen combines with it in the following proportions:— 1; 2; 2.5; 3.

Hyposulphuric acid is distinguished by the following properties:—

1st, It is decomposed by heat into sulphurous and sulphuric acids.

2d, It forms soluble salts with barytes, strontites, lime, lead, and silver.

3d, The hyposulphates are all soluble.

4th, They yield sulphurous acid when their solutions are mixed with acids, only if the mixture becomes hot of itself, or be artificially heated.

5th, They disengage a great deal of sulphurous acid at a high temperature, and are converted into neutral sulphates.

Before quitting the acids of sulphur, it deserves to be mentioned, that Dr. Gulès, of Paris, has, by means of a chest or case, called Boëte Fumigatoire, applied the vapour of burning sulphur, or sulphurous acid gas, mixed with air, to the surface of the body, as an air bath, with great advantage, in many chronic diseases of the skin, the joints, the glands, and the lymphatic system.—See SALT.

ACID (SULPHO-NAPHTHALIC). Mr. Faraday communicated a paper, in 1826, to the Royal Society, to show that during the mutual action of sulphuric acid and naphthaline, a compound of that acid with hydro-carbon is formed, differing from all known substances, and which possessing acid properties, and combining with salifiable bases to produce a peculiar class of salts, has been distinguished as the sulpho-naphthalic acid. Let two parts of naphthaline and one part of concentrated sulphuric acid be introduced into a flask, raise the temperature till the naphthaline melts, and agitate. Combination is effected, and, after cooling, two substances are found, both in the solid state. The lighter is naphthaline, containing a little of the peculiar acid. The lower and heavier is also crystalline, but softer than the upper. It is red, of an acid bitter taste, absorbs moisture from the air, and consists principally of the hydrated peculiar acid, containing some uncombined naphthaline. It is distinguished as the *impure solid acid.* On rubbing this with native carbonate of barytes in a mortar, a soluble barytic salt was obtained. To the solution of this salt, sulphuric acid was carefully added just in quantity sufficient to precipitate the barytes; and after filtration a pure aqueous solution of the new acid was obtained. This solution is bitter, acid, powerfully reddening vegetable blues, neutralising bases, but not precipitating barytes or lead from their salts. When carefully evaporated *in vacuo*, it affords a white, solid, crystalline acid, deliquescing in the air. It melts at 212° Fahr. and crystallizes on cooling. Its salts are soluble in water and alcohol. That of barytes is composed of an atom of barytes, 2 of sulphuric acid, 20 of charcoal, and 8 of hydrogen. Its saturating power is equal to one half that of its sulphuric acid.

ACID (SULPHOVINIC). Salts called sulphovinates were first noticed about the year 1800 by M. Dabit, and afterwards treated of by M. Vogel; but their nature was never ascertained till Mr. Hennel made his investigations lately on the subject. The sulphovinates are readily prepared by mixing equal weights of sulphuric acid and alcohol; allowing the mixture to remain for half an hour, then adding carbonate of lead equal in weight to that of the sulphuric acid first used, and, filtering, little else than sulphovinic acid is left in solution. This combined with bases furnishes salts, which may be rendered pure by crystallization. Sulphovinic acid, according to Mr. Hennel, consists of two atoms of sulphuric acid, four of hydrogen, and four of carbon; and this compound acid combines with one atom of potash to form sulphovinate of potash. The vegetable part of the acid is therefore olefiant gas. Oil of wine and sulphovinic acid seem to be identical. *Phil. Trans.* 1826. *Part* 3. See OIL OF WINE.

ACID (TARTARIC). The casks in which some kinds of wine are kept become incrusted with a hard substance, tinged with the colouring matter of the wine, and otherwise impure, which has long been known by the name of *argal*, or tartar, and distinguished into red and white, according to its colour. This being purified was termed *cream*, or *crystals of tartar*. It was afterwards discovered, that it consisted of a peculiar acid combined with potash; and the supposition that it was formed during the fermentation of the wine was disproved by Boerhaave, Neuman, and others, who showed that it existed ready formed in the juice of the grape. It has likewise been found in other fruits, particularly before they are too ripe; and in the tamarind, sumac, balm, carduus benedictus, and the roots of restharrow, germander, and sage. The separation of tartaric acid from this acidulous salt is the first discovery of Scheele that is known. He saturated the superfluous acid, by adding chalk to a solution of the supertartrate in boiling water as long as any effervescence ensued, and expelled the acid from the precipitated tartrate of lime by means of the sulphuric. Or four parts of tartar may be boiled in twenty or twenty-four of water, and one part of sulphuric acid added gradually. By continuing the boiling, the sulphate of potash will fall down. When the liquor is reduced to one-half, it is to be filtered; and if any more sulphate be deposited by continuing the boiling, the filtering must be repeated. When no more is thrown down, the liquor is to be evaporated to the consistence of a syrup; and thus crystals of impure tartaric acid, equal to half the weight of the tartar employed, will be obtained.

Tartaric acid may be procured by careful evaporation in large crystals, which, when insulated, are found to be hexaëdral prisms, with faces parallel, two and two. The four angles which are most obtuse are equal to one another, measuring each 129°; the two remaining ones are also equal, and measure 102°. The prism is terminated by a three-sided pyramid, the inclinations of whose faces are 102.5, 122°, and 125°. The prisms are sometimes much compressed in a direction parallel to the axis. This takes place when the acid has been very slowly crystallized by evaporating a solution of it. Its taste is very acid and agreeable, so that it may supply the place of lemon-juice. It is very soluble in water. Burnt in an open fire, it leaves a coaly residuum; in close vessels it gives out carbonic acid and carburetted hydrogen gas. By distilling nitric acid off the crystals, they may be converted into oxalic acid, and the nitric acid passes to the state of nitrous.

To extract the whole acid from tartar, M. Thenard recommends, after saturating the redundant acid with chalk, to add muriate of lime to the supernatant neutral tartrate, by which means it is completely decomposed. The insoluble tartrate of lime being washed with abundance of water, is then to be treated with three-fifths of its weight of strong sulphuric acid, diluted previously with five parts of water. But Fourcroy's process, as improved by Vauquelin, seems cheaper. Tartar is treated with quicklime and boiling water in the proportion, by the theory of equivalents, of 100 of tartar to 30 of dry lime, or 40 of the slaked. A caustic magma is obtained, which must be evaporated to dryness, and gently heated. On digesting this in water, a solution of caustic potash is obtained, while tartrate of lime remains; from which the acid may be separated by the equivalent quantity of oil of vitriol.

According to Berzelius, tartaric acid is a compound of 3.807 hydrogen + 35.980 carbon + 60.213 oxygen = 100; to which result he shows that of M. Gay Lussac and Thenard to correspond, when allowance is made for a certain portion of water, which they had omitted to estimate. The analysis of tartrate of lead, gives 8.384 for the acid prime equivalent; and it may be made up of

3 hydrogen	= 0.375	4.48
4 carbon	= 3.000	35.82
5 oxygen	= 5.000	59.70
	8.375	100.00

The crystallized acid is a compound of 8.375 acid + 1.125 water = 9.5; or in 100 parts 88.15 acid + 11.85 water.

The prime equivalent of tartaric acid in crystals is, by my results, 9.25; and it seems made up of carbon 4 atoms = 3 + hydrogen 2 atoms = 0.25 + oxygen 6 = 6; or of carbon 4 atoms, oxygen 4 atoms, and water 2. These atoms of water enter into dry tartrate of lead; and hence the crystals of acid contain no water unessential to their constitution. *Phil. Trans.* 1822.

Mr. Rose has shown, that tartaric acid has a peculiar influence in several cases of chemical analysis. When a solution of red oxide of iron is mixed with tartaric acid, the oxide can be precipitated neither by caustic alkalis, nor by their carbonates or succinates; but tincture of galls, triple prussiate of potash, and alkaline hydrosulphurets, show the presence of iron in such a solution. The same thing is true of the oxides of titanium, manganese, cerium, yttrium, cobalt, and nickel, as well as with alumina and magnesia. Solution of protosulphate of iron with tartaric acid is merely rendered intensely green by ammonia, and changes after long standing in the air to a yellow coloured solution, which contains iron.

The oxide of lead likewise is not separable by alkalis when its solution has been treated with so much nitric acid that no tartrate of lead can precipitate. Oxides of tin and copper fall under the same head. Lastly, oxide of antimony, when its solution in an acid is mixed with the tartaric, resists both alkalis and the most copious dilution with water. Thus, oxide of bismuth may be separated from oxide of antimony; for the former resists the influence of tartaric acid. Muriate of platinum, the oxides of silver, zinc, and uranium, are not altered by tartaric acid.—*Gilbert's Ann.* lxxiii. 74.

The tartrates in their decomposition by fire comport themselves like all the other vegetable salts, except that those with excess of acid yield the smell of *caromel* when heated, and afford a certain quantity of the pyrotartaric acid. All the soluble neutral tartrates form, with tartaric acid, bitartrates of sparing solubility; while all the insoluble tartrates may be dissolved in an excess of their acid. Hence, by pouring gradually an excess of acid into barytes, strontites, and lime waters, the precipitates formed at first cannot fail to disappear; while those obtained by an excess of the same acid, added to concentrated solutions of potash, soda, or ammonia, and the neutral tartrates of these bases as well as of magnesia and copper, must be permanent. The first are always flocculent; the second always crystalline; that of copper alone, is in a greenish-white powder. It likewise follows, that the greater number of acids ought to disturb the solutions of the alkaline neutral tartrates, because they transform these salts into bitartrates; and on the contrary they ought to affect the solution of the neutral insoluble tartrates, which indeed always happens, unless the acid cannot dissolve the base of the tartrate. The order of apparent affinities of tartaric acid are, lime, barytes, strontites, potash, soda, ammonia, and magnesia.

The tartrates of potash, soda, and ammonia, are not only susceptible of combining together, but also with the other tartrates, so as to form double or triple salts. We may thus easily conceive why the tartrates of potash, soda, and ammonia, do not disturb the solutions of iron and manganese; and on the other hand, disturb the solutions of the salts of barytes, strontites, lime, and lead. In the first case, double salts are formed, however small a quantity of tartrate shall have been employed; in the second, no double salt is formed, unless the tartrate be added in very great excess.

The tartrates of lime and barytes are white, pulverulent, and insoluble.

Tartrate of strontian, formed by the double decomposition of muriate of strontian and tartrate of potash, according to Vauquelin, is soluble, crystallizable, and consists of 52.88 strontian and 47.12 acid.

That of magnesia forms a gelatinous or gummy mass.

Tartrate of potash, formerly called *soluble tartar*, because much more so than the supertartrate, crystallizes in oblong squares, bevelled at the extremities. It has a bitterish taste, and is decomposed by heat, as its solution is even by standing some time. It is used as a mild purgative.

The supertartrate of potash, already mentioned at the beginning of this article, is much used as a cooling and gently opening medicine, as well as in several chemical and pharmaceutical preparations. Mixed with an equal weight of nitre, and projected into a red-hot crucible, it detonates, and forms the *white flux*; treated in the same way with half its weight of nitre, it forms the *black flux*; and simply mixed with nitre in various proportions, it is called *raw flux*. It is likewise used in dyeing, in hat-making, in gilding, and in other arts.

The blanching of the crude tartar is aided by boiling its solution with $\frac{1}{20}$ of pipe clay.

According to the analysis of Berzelius, it consists of 70.45 acid + 24.8 potash + 4.75 water = 100; or

2 primes	acid,	=	16.75	70.30
1	potash,	=	5.95	24.95
1	water,	=	1.125	4.75
			23.825	100.00

60 parts of water dissolve 4 of bitartrate at a boiling heat; and only 1 at 60° Fahr. It is quite insoluble in alcohol. It becomes very soluble in water, by adding to it one-fifth of its weight of borax; or even by the addition of boracic acid. It appears by Berzelius, that neutral tartrate of potash, dried in the sun, differs from the bitartrate, in containing no water of crystallization. He states it to be a compound of 58.69 acid + 41.31 potash = 100; which afford 155.7 tartrate of lead. Now, 8.375 : 5.95 : : 58.5 : 41.5; which are the equivalent proportions.

On considering the great solvent property of cream of tartar, and that it is even capable of dissolving various oxides, which are insoluble in tartaric acid, as the protoxide of antimony, M. Gay Lussac has recommended it as a useful agent in chemical analysis. He thinks that in many cases it acts the part of a single acid. According to this view, tartar emetic would be a compound of the *cream-tartar* acid, and protoxide of antimony. Cream of tartar generally contains from 3 to 5 per cent. of tartrate of lime, which are in a great measure separated when 8 parts of tartar are boiled with 1 of borax for a few minutes in a sufficient quantity of water. The soluble cream of tartar which is obtained by this process is deliquescent; it dissolves in its own weight of boiling water, at 54.5°, and in half its weight of boiling water. Its solution is very imperfectly decomposed by the sulphuric, nitric, and muriatic acids. 4 parts of tartar and 1 of boracic acid form a permanent saline compound, very soluble in water. Alum also increases the solubility of tartar.

By saturating the superfluous acid in this supertartrate with soda, a triple salt is formed, which crystallizes in larger regular prisms of eight nearly equal sides, of a bitter taste, efflorescent, and soluble in about five parts of water. It consists, according to Vauquelin, of 54 parts tartrate of potash and 46 tartrate of soda; and was once in much repute as a purgative by the name of *Rochelle Salt* or *sel de Seignette*.

The tartrate of soda is much less soluble than this triple salt, and crystallizes in slender needles or thin plates.

The tartrate of ammonia is a very soluble, bitter salt, and crystallizes easily. Its solution is spontaneously decomposable.

This too forms, with tartrate of potash, a triple salt, the solution of which yields, by cooling, fine pyramidal or prismatic efflorescent crystals. Though both the neutral salts that compose it are bitter, this is not, but has a cooling taste. See SALT.

M. Fabroni says, that sulphuric acid being mixed with three parts of boiling water and cream of tartar in excess, gives a fluid which, after being evaporated, cooled, and allowed to deposit undecomposed tartar, sulphate of potash, &c. will not furnish any other deposit, and resembles oil in its appearance. When further evaporated to the consistence of syrup, and again cooled, it solidifies in a mass composed of imperfect prismatic crystals, which when dry have something the appearance of camphor. It dissolves rapidly in water, but in alcohol yields its tartaric acid, while acid sulphate of potash is left. On analysis it gave 72 tartaric acid, and 28 sulphate of potash. *Gior. de Fisica*, vi. 452.

ACID (TITANIC). By fusing powdered rutilite with thrice its weight of carbonate of potash, dissolving the compound in muriatic acid, precipitating by caustic ammonia, digesting the precipitate for a certain time with hydrosulphuret of ammonia, and then digesting the solid matter left in weak muriatic acid, Mr. Rose obtains a perfectly white oxide of titanium, which is not attacked by acids, but which becomes red by touching moistened litmus. As it acts with alkalis precisely as an acid, Mr. Rose calls it titanic acid.

It is said to consist of titanium 66.05
oxygen 33.95;

whence if, like the other metallic acids, this be supposed to contain 3 atoms of oxygen, the atomic weight of the metal will be 5.83, or possibly 6.

Acid titanate of potash consists of,

titanic acid . .	82.33	100.
potash . . .	17.77	

Acid titanate of soda,

titanic acid . .	83.15	100.
soda	16.85	

Sulpho-titanic acid consists of,

titanic acid . .	76.67	100.
sulphuric acid .	7.67	
water	15.66	

Oxalo-titanic acid of; titanic acid 74.1; oxalic acid 10.4; water 15.5.

Sulphuret of titanium consists of titanium 49.17; sulphur 50.83.

Protochloride of titanium consists of titanium 6; chlorine 3.6.

Perchloride of titanium consists of titanium 6.66; chlorine 7.94.

Annales de Chim. xxiii. 353. *Annals of Phil.* N. S. ix. 18.

ACID (TUNGSTOUS). What has been thus called appears to be an oxide of TUNGSTEN.

ACID (TUNGSTIC) has been found only in two minerals; one of which, formerly called tungsten, is a tungstate of lime, and is very rare; the other more common, is composed of tungstic acid, oxide of iron, and a little oxide of manganese. The acid is separated from the latter in the following way. The wolfram cleared from its siliceous *gangue*, and pulverized, is heated in a matrass with five or six times its weight of muriatic acid, for half an hour. The oxides of iron and manganese being thus dissolved, we obtain the tungstic acid under the form of a yellow powder. After washing it repeatedly with water, it is then digested in an excess of liquid ammonia, heated, which dissolves it completely. The liquor is filtered and evaporated to dryness in a capsule. The dry residue being ignited, the ammonia flies off, and pure tungstic acid remains. If the whole of the wolfram has not been decomposed in this operation, it must be subjected to the muriatic acid again.

It is tasteless, and does not affect vegetable colours. The tungstates of the alkalis and magnesia are soluble and crystallizable; the other earthy ones are insoluble, as well as those of the metallic oxides. The acid is composed of 100 parts metallic tungsten, and 25 or 26.4 oxygen.

ACID (URIC). The same with LITHIC ACID; which see.

ACID (ZOONIC). In the liquid procured by distillation from animal substances, which had been supposed to contain only carbonate of ammonia and an oil, Berthollet imagined he had discovered a peculiar acid, to which he gave the name of zoonic. Thenard, however, has demonstrated that it is merely acetic acid combined with animal matter.

ACIDIFIABLE. Capable of being converted into an acid by an acidifying principle. (See ACID.) Substances possessing this property are called *radicals*, or *acidifiable bases*.

ACIDIFYING PRINCIPLE. See remarks on this subject, in the general article ACID.

ACIDIMETRY. The measurement of the strength of acids. This is effected by saturating a given weight of them with an alkaline base; the quantity of which requisite for the purpose is the measure of their power.

ACIDULE. A term applied by the French chemists to those salts in which the base is combined with such an excess of acid, that they manifestly exhibit acid properties; such as the supertartrate of potash.

ACONITA. A poisonous vegetable principle, probably alkaline, supposed to exist in the *aconitum napellus*, or wolfsbane. In some British journals it is stated that Mr. Brandes had procured this alkaline principle. But I observe in his translation of my Dictionary into the German language, that he refers the point to the researches of M. Peschier of Geneva, who has not hitherto made it distinctly out. Buchols analyzed the herb aconite, and found the following constituents in 20 ounces:

	oz.	dr.	gr.
Water and volatile matter	16	6	0
Fibrous matter	1	3	0
Green resin	0	1	50
Vegetable albumen (*Pflanzeneiweiss*)	0	3	55
Extractive with various acetates and muriates	0	4	50
Gummy matter	0	6	0
Malate and citrate of lime	0	1	56
	20	2	30

The distilled water of aconite, though smelling rank of the plant, is not poisonous. The noxious principle is therefore not volatile. The details of the analysis have not reached this country.

ACROSPIRE. The *plumula* is that part of the embryon of a plant destined to become the stem, and which bears the cotylidons. According to Grew, the acrospire is the *plumula* of barley developed by germination. It is sometimes named *plantula.*

ACTINOLITE. *Strahlstein* of Werner. *Amphibole Actinote hexaèdre* of Hauy. There are three varieties of this mineral; the *crystallized*, the *asbestous*, and the *glassy*.

1*st*, Crystallized actinolite. Colour leek-green, and green of darker shades. It crystallizes in long oblique hexaedral prisms, with irregular terminations. Crystals frequently striated lengthwise, sometimes acicular. Its lustre is shining. It is translucent. Occasionally it is found in silky fibres. Its sp. gr. varies from 3.0 to 3.3. Fracture usually radiated; sometimes it is foliated with an indistinct twofold cleavage. It scratches glass.

2*d*, Asbestous actinolite. Colours green, verging on grey and brown, and smalt-blue. Massive and in elastic capillary crystals, which are grouped in wedge-shaped, radiated, or promiscuous masses. Internal lustre pearly. Melts before the blowpipe into a dark glass. Fracture intermediate between fibrous and narrow radiated. Fragments wedge-shaped. Opaque. Soft. Tough but sectile. Sp. gr. 2.7 to 2.9.

3*d*, Glassy actinolite. Colours, mountain-green, and emerald-green. In thin six-sided needle-form crystals. Has cross rents. Sp. gr. from 3.0 to 3.2. The composition of actinolite is very differently stated by different analysts. Laugier's results with glassy actinolite are the following, and they approximate to those of Vauquelin on asbestous actinolite; silica 50, lime 9.75, magnesia 19.25, oxide of iron 11, alumina 0.75, oxide of manganese 0.5, oxide of chromium 3, potash 0.5, moisture 5, loss 0.25. 28.2 of alumina and 3.84 of tungstic acid were found in 100 parts of asbestous actinolite from Cornwall.

Actinolite is found chiefly in primitive districts, with a magnesian basis. It accompanies talc, and some micaceous rocks. Its principal localities are Zillerthal, in the Tyrol, Mont St. Gothard, near Saltzburg, in Saxony; in Norway, and in Piedmont. In Great Britain, it is found in Cornwall and Wales; and in Glen Elg, the isles of Lewis and Sky. It is never found in secondary mountains.

ADAMANT. See DIAMOND.

ADHESION. See COHESION.

ADHESIVE SLATE. See SLATE.

ADIPOCERE. The attention of chemists has been much excited by the spontaneous conversion of animal matter into a substance considerably resembling spermaceti. The fact has long been well known, and is said to have been mentioned in the works of Lord Bacon, though I have not seen the passage. On the occasion of the removal of a very great number of human bodies from the ancient burying-place des Innocens at Paris, facts of this nature were observed in the most striking manner. Fourcroy may be called the scientific discoverer of this peculiar matter, as well as the saponaceous ammoniacal substance contained in bodies abandoned to spontaneous destruction in large masses. This chemist read a memoir on the subject in the year 1789 to the Royal Academy of Sciences, from which I shall abstract the general contents.

At the time of clearing the before mentioned burying-place, certain philosophers were specially charged to direct the precautions requisite for securing the health of the workmen. A new and singular object of research presented itself, which had been necessarily unknown to preceding chemists. It was impossible to foretell what might be the contents of a soil overloaded for successive ages with bodies resigned to the putrefactive process. This spot differed from common burying-grounds, where each individual object is surrounded by a portion of the soil. It was the burying-ground of a large district, wherein successive generations of the inhabitants had been deposited for upwards of three centuries. It could not be foreseen that the entire decomposition might be retarded for more than forty years; neither was there any reason to suspect that any remarkable difference would arise from the singularity of situation.

The remains of the human bodies immersed in this mass of putrescence were found in three different states, according to the time they had been buried, the place they occupied, and their relative situations with regard to each other. The most ancient were simply portions of bones, irregularly dispersed in the soil, which had been frequently disturbed. A second state, in certain bodies which had always been insulated, exhibited the skin, the muscles, tendons, and aponeuroses, dry, brittle, hard, more or less grey, and similar to what are called mummies in certain caverns where this change has been observed, as in the catacombs at Rome, and the vault of the Cordeliers at Tholouse.

The third and most singular state of these soft parts was observed in the bodies which filled the common graves or repositories. By this appellation are understood cavities of thirty feet in depth, and twenty on each side, which were dug in the burying-ground of the Innocents, and were appropriated to contain the bodies of the poor; which were placed in very close rows, each in its proper wooden bier. The necessity for disposing a great number, obliged the men charged with this employment to arrange them so near each other, that these cavities might be considered when filled as an entire mass of human bodies separated only by two planks of about half an inch thick. Each cavity contained between one thousand and fifteen hundred. When one common grave of this magnitude was filled, a covering of about one foot deep of earth was laid upon it, and another excavation of the same sort was made at some distance. Each grave remained open about three years, which was the time required to fill it. According to the urgency of circumstances, the graves were again made on the same spot after an interval of time, not less than fifteen years, nor more than thirty. Experience had taught the workmen, that this time was not sufficient for the entire destruction of the bodies, and had shown them the progressive changes which form the object of M. Fourcroy's memoir.

The first of these large graves opened in the presence of this chemist had been closed for fifteen years. The coffins were in good preservation, but a little settled, and the wood (I suppose deal) had a yellow tinge. When the covers of several were taken off, the bodies were observed at the bottom, leaving a considerable distance between their surface and the cover, and flattened as if they had suffered a strong compression. The linen which had covered them was slightly adherent to the bodies; and, with the form of the different regions, exhibited, on removing the linen, nothing but irregular masses of a soft ductile matter of a grey-white colour. These masses environed the bones on all sides, which had no solidity, but broke by any sudden pressure. The appearance of this matter, its obvious composition and its softness, resembled common white cheese; and the resemblance was more striking from the print which the threads of the linen had made upon its surface. This white substance yielded to the touch, and became soft when rubbed for a time between the fingers.

No very offensive smell was emitted from these bodies. The novelty and singularity of the spectacle, and the example of the grave-diggers, dispelled every idea either of disgust or apprehension. These men asserted that they never found this matter, by them called *gras* (fat), in bodies interred alone; but that the accumulated bodies of the common graves only were subject to this change. On a very attentive examination of a number of bodies passed to this state, M. Fourcroy remarked that the conversion appeared in different stages of advancement, so that, in various bodies, the fibrous texture and colour, more or less red, were discernible within the fatty matter; that the masses covering the bones were entirely of the same nature, offering indistinctly in all the regions a grey substance, for the most part soft and ductile, sometimes dry, always easy to be separated in porous fragments, penetrated with cavities, and no longer exhibiting any traces of membranes, muscles, tendons, vessels, or nerves. On the first inspection of these white masses, it might have been concluded that they were simply the cellular tissue, the compartments and vesicles of which they very well represented.

By examining this substance in the different regions of the body, it was found that the skin is particularly disposed to this remarkable alteration. It was afterwards perceived that the ligaments and tendons no longer existed, or at least had lost their tenacity; so that the bones were entirely unsupported, and left to the action of their own weight. Whence their relative places were preserved in a certain degree by mere juxtaposition; the least effort being sufficient to separate them. The grave-diggers availed themselves of this circumstance in the removal of the bodies. For they rolled them up from head to feet, and by that means separated from each other the extremities of the bones, which had formerly been articulated. In all those bodies which were changed into the fatty matter, the abdominal cavity had disappeared. The teguments and muscles of this region being converted into the white matter, like the other soft parts, had subsided upon the vertebral column, and were so flattened as to leave no place for the viscera; and accordingly there was scarcely ever any trace observed in the almost obliterated cavity. This observation was for a long time matter of astonishment to the investigators. In vain did they seek, in the greater number of bodies, the place and substance of the stomach, the intestines, the bladder, and even the liver, the spleen, the kidneys, and the matrix in females. All these viscera were confounded together, and for the most part no traces of them were left. Sometimes only certain irregular masses were found, of the same nature as the white matter, of different bulks, from that of a nut to two or three inches in diameter, in the regions of the liver or of the spleen.

The thorax likewise offered an assemblage of facts no less singular and interesting. The external part of this cavity was flattened and compressed like the rest of the organs; the ribs, spontaneously luxated in their articulations with the vertebræ, were settled upon the dorsal column; their arched part left only a small space on each side between them and the vertebræ. The pleura, the mediastines, the large vessels, the aspera arteria, and even the lungs and the heart, were no longer distinguishable; but for the most part had entirely disappeared, and in their place nothing was seen but some parcels of the fatty substance. In this case, the matter which was the product of decomposition of the viscera, charged with blood and various humours, differs from that of the surface of the body, and the long bones, in the red or brown colour possessed by the former. Sometimes the observers found in the thorax a mass irregularly rounded, of the same nature as the latter, which appeared to them to have arisen from the fat and fibrous substance of the heart. They supposed that this mass, not constantly found in all the subjects, owed its existence to a superabundance of fat in this viscus, where it was found. For the general observation presented itself, that, in similar circumstances, the fat parts undergo this conversion more evidently than the others, and afford a larger quantity of the white matter.

The external region in females exhibited the glandular and adipose mass of the breasts converted into the fatty matter, very white and very homogeneous.

The head was, as has already been remarked, environed with the fatty matter; the face was no longer distinguishable in the greatest number of subjects; the mouth disorganized, exhibited neither tongue nor palate; and the jaws, luxated and more or less displaced, were environed with irregular layers of the white matter. Some pieces of the same matter usually occupied the place of the parts situated in the mouth; the cartilages of the nose participated in the general alteration of the skin; the orbits, instead of eyes, contained white masses; the ears were equally disorganized; and the hairy scalp, having undergone a similar alteration to that of the other organs, still retained the hair. M. Fourcroy remarks incidentally, that the hair appears to resist every alteration much longer than any other part of the body. The cranium constantly contained the brain contracted in bulk; blackish at the surface, and absolutely changed like the other organs. In a great number of subjects which were examined, this viscus was never found wanting, and it was always in the above-mentioned state; which proves that the substance of the brain is greatly disposed to be converted into the fat matter.

Such was the state of the bodies found in the burial-ground des Innocens. Its modifications were also various. Its consistence in bodies lately changed, that is to say, from three to five years, was soft and very ductile, containing a great quantity of water. In other subjects converted into this matter for a long time, such as those which occupied the cavities which had been closed thirty or forty years, this matter is drier, more brittle, and in denser flakes. In several which were deposited in dry earth, various portions of the fatty matter had become semitransparent. The aspect, the granulated texture, and brittleness of this dried matter, bore a considerable resemblance to wax.

The period of the formation of this substance had likewise an influence on its properties. In general, all that had been formed for a long time was white, uniform, and contained no foreign substance, or fibrous remains; such, in particular, was that afforded by the skin of the extremities. On the contrary, in bodies recently changed, the fatty matter was neither so uniform nor so pure as in the former; but it was still found to contain portions of muscles, tendons, and ligaments, the texture of which, though already altered and changed in its colour, was still distinguishable. Accordingly, as the conversion was more or less advanced, these fibrous remains were more or less penetrated with the fatty matter, interposed as it were between the interstices of the fibres. This observation shows, that it is not merely the fat which is thus changed, as was natural enough to think at first sight. Other facts confirm this assertion. The skin, as has been remarked, becomes easily converted into very pure white matter, as does likewise the brain, neither of which has been considered by anatomists to be fat. It is true, nevertheless, that the unctuous parts, and bodies charged with fat, appear more easily and speedily to pass to the state under consideration. This was seen in the marrow, which occupied the cavities of the longer bones. And again, it is not to be supposed but that the greater part of these bodies had been emaciated by the illness which terminated their lives; notwithstanding which, they were all absolutely turned into this fatty substance.

An experiment made by M. Poulletier de la Salle, and Fourcroy likewise, evinced that a conversion does not take place in the fat alone. M. Poulletier had suspended in his laboratory a small piece of the human liver, to observe what would arise to it by the contact of the air. It partly putrefied, without, however, emitting any very noisome smell. Larvæ of the dermestes and bruchus attacked and penetrated it in various directions: at last it became dry, and after more than ten years' suspension, it was converted into a white friable substance resembling dried agaric, which might have been taken for an earthy substance. In this state it had no perceptible smell. M. Poulletier was desirous of knowing the state of this animal matter, and experiment soon convinced him and M. F. that it was very far from being in the state of an earth. It melted by heat, and exhaled in the form of vapour, which had the smell of a very fetid fat; spirit of wine separated a concrescible oil, which appeared to possess all the properties of spermaceti. Each of the three alkalis converted it into soap; and, in a word, it exhibited all the properties of the fatty matter of the burial-ground of the Innocents exposed for several months to the air. Here then was a glandular organ, which in the midst of the atmosphere had undergone a change similar to that of the bodies in the burying-place; and this fact sufficiently shows, that an animal substance, which is very far from being of the nature of grease, may be totally converted into this fatty substance.

Among the modifications of this remarkable substance in the burying-ground before mentioned, it was observed that the dry, friable, and brittle matter, was most commonly found near the surface of the earth, and the soft ductile matter at a greater depth. M. Fourcroy remarks, that this dry matter did not differ from the other merely in containing less water, but likewise by the volatilization of one of its principles.

The grave-diggers assert, that near three years are required to convert a body into this fatty substance. But Dr. Gibbes of Oxford found, that lean beef secured in a running stream was converted into this fatty matter at the end of a month. He judges from facts, that running water is most favourable to this process. He took three lean pieces of mutton, and poured on each a quantity of the three common mineral acids. At the end of three days, each was much changed: that in the nitric acid was very soft, and converted into the fatty matter; that in the muriatic acid was not in that time so much altered; the sulphuric acid had turned the other black. M. Lavoisier thinks that this process may hereafter prove of great use in society. It is not easy to point out what animal substance, or what situation, might be the best adapted for an undertaking of this kind. M. L. points out fecal matters; but I have not heard of any conversion having taken place in these animal remains, similar to that of the foregoing.

The result of M. Fourcroy's inquiries into the ordinary changes of bodies recently deposited in the earth, was not very extensive. The grave-diggers informed him, that those bodies interred do not perceptibly change colour for the first seven or eight days; that the putrid process disengages elastic fluid, which inflates the abdomen, and at length bursts it; that this event instantly causes vertigo, faintness, and nausea in such persons as unfortunately are within a certain distance of the scene where it takes place; but that when the object of its action is nearer, a sudden privation of sense, and frequently death, is the consequence. These men are taught by experience, that no immediate danger is to be feared from the disgusting business they are engaged in, excepting at this period, which they regard with the utmost terror. They resisted every inducement and persuasion which these philosophers made use of, to prevail on them to assist their researches into the nature of this active and pernicious vapour. M. Fourcroy takes occasion from these facts, as well as from the pallid and unwholesome appearance of the grave-diggers, to reprobate burials in great towns or their vicinity.

Such bodies as are interred alone, in the midst of a great quantity of humid earth, are totally destroyed by passing through the successive degrees of the ordinary putrefaction; and this destruction is more speedy, the warmer the temperature. But if these insulated bodies be dry and emaciated; if the place of deposition be likewise dry, and the locality and other circumstances such, that the earth, so far from receiving moisture from the atmosphere, becomes still more effectually parched by the solar rays;—the animal juices are volatilized and absorbed, the solids contract and harden, and a peculiar species of mummy is produced. But every circumstance is very different in the common burying-grounds. Heaped together almost in contact, the influence of external bodies affects them scarcely at all, and they become abandoned to a peculiar disorganization, which destroys their texture, and produces the new and most permanent state of combination here described. From various observations, which I do not here extract, it was found, that this fatty matter was capable of enduring in these burying-places for thirty or forty years, and is at length corroded and carried off by the aqueous putrid humidity which there abounds.

Among other interesting facts afforded by the chemical examination of this substance, are the following from experiments by M. Fourcroy.

1. This substance is fused at a less degree of heat than that of boiling water, and may be purified by pressure through a cloth, which disengages a portion of fibrous and bony matter. 2. The process of destructive distillation by a very graduated heat was begun, but not completed on account of its tediousness, and the little promise of advantage it afforded. The products which came over were water charged with volatile alkali, a fat oil, concrete volatile alkali, and no elastic fluid during the time the operation was continued. 3. Fragments of the fatty matter exposed to the air during the hot and dry summer of 1786 became dry, brittle, and almost pulverulent at the surface. On a careful examination, certain portions were observed to be semitransparent, and more brittle than the rest. These possessed all the apparent properties of wax, and did not afford volatile alkali by distillation. 4. With water this fatty matter exhibited all the appearances of soap, and afforded a strong lather. The dried substance did not form the saponaceous combination with the same facility or perfection as that which was recent. About two-thirds of this dried matter separated from the water by cooling, and proved to be the semitransparent substance resembling wax.

This was taken from the surface of the soapy liquor, which being then passed through the filter, left a white soft shining matter, which was fusible and combustible. 5. Attempts were made to ascertain the quantity of volatile alkali in this substance, by the application of lime, and of the fixed alkalis, but without success: for it was difficult to collect and appreciate the first portions which escaped, and likewise to disengage the last portions. The caustic volatile alkali, with the assistance of a gentle heat, dissolved the fatty matter, and the solution became perfectly clear and transparent at the boiling temperature of the mixture, which was at 185° F. 6. Sulphuric acid, of the specific gravity of 2.0, was poured upon six times its weight of the fatty matter, and mixed by agitation. Heat was produced, and a gas or effluvium of the most insupportable putrescence was emitted, which infected the air of an extensive laboratory for several days. M. Fourcroy says, that the smell cannot be described, but that it is one of the most horrid and repulsive that can be imagined. It did not, however, produce any indisposition either in himself or his assistants. By dilution with water, and the ordinary processes of evaporation and cooling, properly repeated, the sulphates of ammonia and of lime were obtained. A substance was separated from the liquor, which appeared to be the waxy matter, somewhat altered by the action of the acid. 7. The nitrous and muriatic acids were also applied, and afforded phenomena worthy of remark, but which for the sake of conciseness are here omitted. 8. Alcohol does not act on this matter at the ordinary temperature of the air. But by boiling it dissolves one-third of its own weight, which is almost totally separable by cooling as low as 55°. The alcohol, after this process, affords by evaporation a portion of that waxy matter which is separable by acids, and is therefore the only portion soluble in cold alcohol. The quantity of fatty matter operated on was 4 ounces, or 2304 grains, of which the boiling spirit took up the whole except 26 grains, which proved to be a mixture of 20 grains of ammoniacal soap, and 6 or 8 grains of the phosphates of soda and of lime. From this experiment, which was three times repeated with similar results, it appears that alcohol is well suited to afford an analysis of the fatty matter. It does not dissolve the neutral salts; when cold, it dissolves that portion of concrete animal oil from which the volatile alkali had flown off; and when heated, it dissolves the whole of the truly saponaceous matter, which is afterwards completely separated by cooling. And accordingly it was found, that a thin plate of the fatty matter, which had lost nearly the whole of its volatile alkali, by exposure to the air for three years, was almost totally dissolved by the cold alcohol.

The concrete oily or waxy substance obtained in these experiments constitutes the leading object of research, as being the peculiar substance with which the other well known matters are combined. It separates spontaneously by the action of the air, as well as by that of acids. These last separate it in a state of greater purity, the less disposed the acid may be to operate in the way of combustion. It is requisite, therefore, for this purpose, that the fatty matter should be previously diffused in 12 times its weight of hot water; and the muriatic or acetous acid is preferable to the sulphuric or the nitrous. The colour of the waxy matter is greyish; and though exposure to the air, and also the action of the oxygenated muriatic acid did produce an apparent whiteness, it nevertheless disappeared by subsequent fusion. No method was discovered by which it could be permanently bleached.

The nature of this wax or fat is different from that of any other known substance of the like kind. When slowly cooled after fusion, its texture appears crystalline or shivery, like spermaceti; but a speedy cooling gives it a semitransparency resembling wax. Upon the whole, nevertheless, it seems to approach more nearly to the former than to the latter of these bodies. It has less smell than spermaceti, and melts at 127° F.; Dr. Bostock says 92°. Spermaceti requires 6° more of heat to fuse it (according to Dr. Bostock 20°). The spermaceti did not so speedily become brittle by cooling as the adipocere. One ounce of alcohol of the strength between 39 and 40 degrees of Baumé's aerometer, dissolved when boiling hot 12 gros of this substance, but the same quantity in like circumstances dissolved only 30 or 36 grains of spermaceti. The separation of these matters was also remarkably different, the spermaceti being more speedily deposited, and in a much more regular and crystalline form. Ammonia dissolves with singular facility, and even in the cold, this concrete oil separated from the fatty matter; and by heat it forms a transparent solution, which is a true soap. But no excess of ammonia can produce such an effect with spermaceti.

M. Fourcroy concludes his memoir with some speculations on the change to which animal substances in peculiar circumstances are subject. In the modern chemistry, soft animal matters are considered as a composition of the oxides of hydrogen and carbonated azote, more complicated than those of vegetable matters, and therefore more incessantly tending to alteration. If then the carbon be conceived to unite with the oxygen, either of the water which is present, or of the other animal matters, and thus escape in large quantities in the form of carbonic acid gas, we shall perceive the reason why this conversion is attended with so great a loss of weight, namely, about nine-tenths of the whole. The azote, a principle so abundant in animal matters, will form ammonia by combining with the hydrogen; part of this will escape in the vaporous form, and the rest will remain fixed in the fatty matter. The residue of the animal matters deprived of a great part of their carbon, of their oxygen, and the whole of their azote, will consist of a much greater proportion of hydrogen, together with carbon and a minute quantity of oxygen. This, according to the theory of M. Fourcroy, constitutes the waxy matter, or adipocere, which, in combination with ammonia, forms the animal soap, into which the dead bodies are thus converted.

Muscular fibre, macerated in dilute nitric acid, and afterwards well washed in warm water, affords pure adipocere, of a light yellow colour, nearly of the consistence of tallow, of a homogeneous texture, and of course free from ammonia. This is the mode in which it is now commonly procured for chemical experiment.

This curious substance has been more recently examined by Chevreul. He found it composed of a small quantity of ammonia, potash, and lime, united to much margarine, and to a very little of another fatty matter different from that. Weak muriatic acid seizes the three alkaline bases. On treating the residue with a solution of potash, the margarine is precipitated in the form of a pearly substance, while the other fat remains dissolved. Fourcroy being of opinion that the fatty matter of animal carcases, the substance of biliary calculi, and spermaceti, were nearly identical, gave them the same name of adipocere; but it appears from the researches of M. Chevreul that these substances are very different from each other.

In the Philosophical Transactions for 1813 there is a very interesting paper on the above subject by Sir E. Home and Mr. Brande. He adduces many curious facts to prove that adipocere is formed by an incipient and incomplete putrefaction. Mary Howard, aged 44, died on the 12th May 1790, and was buried in a grave ten feet deep at the east end of Shoreditch church-yard, ten feet to the east of the great common sewer, which runs from north to south, and has always a current of water in it, the usual level of which is eight feet below the level of the ground, and two feet above the level of the coffins in the graves. In August 1811 the body was taken up, with some others buried near it, for the purpose of building a vault, and the flesh in all of them was converted into adipocere or spermaceti. At the full and new moon the tide raises water into the graves, which at other times are dry. To explain the extraordinary quantities of fat or adipocere formed by animals of a certain intestinal construction, Sir E. observes, that the current of water which passes through their colon, while the loculated lateral parts are full of solid matter, places the solid contents in somewhat similar circumstances to dead bodies in the banks of a common sewer.

The circumstance of ambergris, which contains 60 per cent. of fat, being found in immense quantities in the lower intestines of the spermaceti whales, and never higher up than seven feet from the anus, is an undeniable proof of fat being formed in the intestines; and as ambergris is only met with in whales out of health, it is most probably collected there from the absorbents, under the influence of disease, not acting so as to take it into the constitution. In the human colon, solid masses of fat are sometimes met with in a diseased state of that canal, and are called *scybala*. A description and analysis by me of a mass of ambergris, extracted in Perthshire from the rectum of a living woman, were published in a London Medical Journal in September 1817. There is a case communicated by Dr. Babington, of fat formed in the intestines of a girl four and a half years old, and passing off by stool. Mr. Brande found, on the suggestion of Sir E. Home, that muscle digested in bile, is convertible into fat, at the temperature of about 100°. If the substance, however, pass rapidly into putrefaction, no fat is formed. Fæces voided by a gouty gentleman after six days constipation, yielded, on infusion in water, a fatty film. This process of forming fat in the lower intestines by means of bile, throws considerable light upon the nourishment derived from clysters, a fact well ascertained, but which could not be explained. It also accounts for the wasting of the body which so invariably attends all complaints of the lower bowels. It accounts too for all the varieties in the turns of the colon, which we meet with in so great a degree in different animals. This property of the bile explains likewise the formation of fatty concretions in the gall bladder so commonly met with, and which, from these experiments, appear to be produced by the action of the bile on the mucus secreted in the gall bladder; and it enables us to understand how want of the gall bladder in children, from mal-formation, is attended with excessive leanness, notwithstanding a great appetite, and leads to an early death. Fat thus appears to be formed in the intestines, and from thence received into the circulation, and deposited in almost every part of the body. And as there appears to be no direct channels by which any superabundance of it can be thrown out of the body, whenever its supply exceeds the consumption, its accumulation becomes a disease, and often a very distressing one. See Biliary Concretions, Margarine, and Intestinal Concretions.

ADIT, in mining, is a subterraneous passage slightly inclined, about six feet high, and two or three feet wide, begun at the bottom of a neighbouring valley, and continued up to the vein, for the purpose of carrying out the minerals and drawing off the water. If the mine require draining by a steam-engine from a greater depth, the water need be raised only to the level of the adit. There is a good account of the *Cornish adits*, by Mr. W. Philips, Trans. Geol. Soc. vol. ii.; and of adits in general, article *Galerie*, Brogniart's Mineralogy, vol. ii.

ADOPTER, a vessel with two necks placed between a retort and a receiver, and serving to increase the length of the neck of the former. See Laboratory.

ADULARIA. See Felspar.

AERATED ALKALINE WATER. See Acid (Carbonic).

AERIAL ACID. See Acid (Carbonic).

AEROLITE, or Meteoric Stone. See Meteorite.

AEROMETER. The name given by Dr. M. Hall to an ingenious instrument of his invention for making the necessary corrections in pneumatic experiments, to ascertain the mean bulk of the gases. It consists of a bulb of glass $4\frac{1}{2}$ cubic inches capacity, blown at the end of a long tube whose capacity is one cubic inch. This tube is inserted into another tube of nearly equal length, supported on a sole. The first tube is sustained at any height within the second by means of a spring. Five cubic inches of atmospheric air, at a medium pressure and temperature, are to be introduced into the bulb and tube, of the latter of which it will occupy one-half; the other half of this tube, and part of the tube into which it is inserted, are to be occupied by the fluid of the pneumatic trough, whether water or mercury. The point of the tube at which the air and fluid meet is to be marked by the figure 5, denoting 5 cubic inches. The upper and lower halves of the tube are each divided into 5 parts, representing tenths of a cubic inch. The external tube has a scale of inches attached. *Journal of Science*, vol. v. See Gas and Appendix.

AEROSTATION, a name commonly, but not very correctly, given to the art of raising heavy bodies into the atmosphere, by the buoyancy of heated air, or gases of small specific gravity, enclosed in a bag, which, from being usually of a spheroidal form, is called a balloon. Of all the possible shapes, the globular admits the greatest capacity under the least surface. Hence, of two bags of the same capacity, if one be spherical, and the other of any other shape, the former will contain the least quantity of cloth, or the least surface. The spheroidal form is therefore best fitted for aërostation. Varnished lutestring or muslin are employed for the envelopes. The following table shows the relation betwixt the diameters, surfaces, and capacities of spheres:

Diameters.	Surfaces.	Capacities.
1	3.141	0.523
2	12.567	4.188
3	28.274	14.137
4	50.265	33.51
5	78.54	65.45
10	314.159	523.6
15	706.9	1767.1
20	1256.6	4189.
25	1963.5	8181.
30	2827.	14137.
40	5026.	33510.

Having ascertained by experiment the weight of a square foot of the varnished cloth, we find, by inspection in the above table, a multiplier whence we readily compute the total weight of the balloon. A cubic foot of atmospheric air weighs 527 gr. and a cubic foot of hydrogen about 40. But as the gas employed to fill balloons is never pure, we must estimate its weight at something more. And perhaps, taking every thing into account, we shall find it a convenient and sufficiently precise rule for aërostation, to consider every cubic foot of included gas, to have by itself a buoyancy of fully one ounce avoirdupois. Hence a balloon of 10 feet diameter will have an ascensional force of fully 524 oz. or 33 lbs. *minus* the weight of the 314 superficial feet of cloth; and one of 30 feet diameter, a buoyancy of fully 14137 oz., or nearly 890 lbs. *minus* the weight of the 2827 feet of cloth. On this calculation no allowance need be made for the seams of the balloon. See the article Varnish.

ÆTITES, or Eagle Stone, is a name that has been given to a kind of hollow geodes of oxide of iron, often mixed with a larger or smaller quantity of silex and alumina, containing in their cavity some concretions, which rattle on shaking the stone. It is of a dull pale colour, composed of concentric layers of various magnitudes, of an oval or polygonal form, and often polished. Eagles were said to carry them to their nests, whence their name; and superstition formerly ascribed wonderful virtues to them.

AFFINITY (CHEMICAL). See Attraction (Chemical).

AGALMATOLITE. See Bildstein.

AGARICUS; The mushroom, a genus of the order Fungi. Mushrooms appear to approach nearer to the nature of animal matter than any other productions of the vegetable kingdom, as, beside hydrogen, oxygen, and carbon, they contain a considerable portion of nitrogen, and yield ammonia by distillation. Prof. Proust has likewise discovered in them the benzoic acid, and phosphate of lime.

A few of the species are eaten in this country, but many are recorded to have produced poisonous effects. Perhaps it is of importance, that they should be fresh, thoroughly dressed, and not of a coriaceous texture. Our *ketchup* is made by sprinkling mushrooms with salt, and letting them stand till great part is resolved into a brown liquor, which is then boiled up with spices.

In pharmacy two species of *boletus* have formerly been used under the name of agaric. The *B. pini laricis*, or *male agaric* of the shops, was given as a purgative, either in substance, or in an extract made with vinegar, wine, or an alkaline solution: and the *B. igniarius*, spunk, or touchwood, called *female agaric*, was applied externally as a styptic, even after amputations. For this purpose the soft inner substance was taken, and beaten with a hammer to render it still softer. That of the oak was preferred.

The mushrooms, remarkable for the quickness of their growth and decay, as well as for the fœtor attending their spontaneous decomposition, were unaccountably neglected by analytical chemists, though capable of rewarding their trouble, as is evinced by the recent investigations and discoveries of MM. Vauquelin and Braconnot. The insoluble fungous portion of the mushroom, though it resembles woody fibre in some respects, yet being less soluble than it in alkalis, and yielding a nutritive food, is evidently a peculiar product, to which accordingly the name of fungin has been given. Two new vegetable acids, the boletic and fungic, were also fruits of these researches.

1. *Agaricus campestris*, an ordinary article of food, analysed by Vauquelin, gave the following constituents: 1. Adipocere. On expressing the juice of the agaric, and subjecting the remainder to the action of boiling alcohol, a fatty matter is extracted, which falls down in white flakes as the alcohol cools. It has a dirty white colour, a fatty feel like spermaceti, and, exposed to heat, soon melts, and then exhales the odour of grease; 2. An oily matter; 3. Vegetable albumen; 4. The sugar of mushrooms; 5. An animal matter soluble in water and alcohol: on being heated it evolves the odour of roasting meat, like osmazome; 6. An animal matter not soluble in alcohol; 7. Fungin; 8. Acetate of potash.

2. *Agaricus volvaceus* afforded Braconnot fungin, gelatin, vegetable albumen, much phosphate of potash, some acetate of potash, sugar of mushrooms, a brown oil, adipocere, wax, a very fugaceous deleterious matter, uncombined acid, supposed to be the acetic, benzoic acid, muriate of potash, and a deal of water; in all 14 ingredients.

3. *Agaricus acris*, or *piperatus*, was found by Braconnot, after a minute analysis, to contain nearly the same ingredients as the preceding, without the wax and benzoic acid, but with more adipocere.

4. *Agaricus stypticus*. From twenty parts of this Braconnot obtained of resin and adipocere 1.8, fungin 16.7, of an unknown gelatinous substance. a potash salt, and a fugaceous acrid principle, 1.5.

5. *Agaricus bulbosus*, was examined by Vauquelin, who found the following constituents; an animal matter insoluble in alcohol, osmazome, a soft fatty matter of a yellow colour and acrid taste, an acid salt, (not a phosphate). The insoluble substance of the agaric yielded an acid by distillation. In Orfila's Toxicology several instances are detailed of the fatal effects of this species of mushroom on the human body. Dogs were killed within 24 hours by small quantities of it in substance, and also by its watery and alcoholic infusions; but water distilled from it was not injurious. It is curious that the animals experienced little inconvenience after swallowing it, during the first ten hours; stupor, cholera, convulsions, and painful cramps are the usual symptoms of the poison in men. The best remedy is an emetic.

6. *Agaricus theogolus*. In this Vauquelin found sugar of mushrooms, osmazome, a bitter acrid fatty matter, an animal matter not soluble in alcohol, a salt containing a vegetable acid.

7. *Agaricus muscarius*. Vauquelin's analysis of this species is as follows: The two animal matters of the last agaric, a fatty matter, sulphate, phosphate, and muriate of potash, a volatile acid from the insoluble matter. The following account from Orfila of the effects of this species on the animal economy is interesting. Several French soldiers ate, at two leagues from Polosck in Russia, mushrooms of the above kind. Four of them, of a robust constitution, who conceived themselves proof against the consequences under which their feebler companions were beginning to suffer, refused obstinately to take an emetic. In the evening the following symptoms appeared: Anxiety, sense of suffocation, ardent thirst, intense griping pains, a small and irregular pulse, universal cold sweats, changed expression of countenance, violet tint of the nose and lips, general trembling, fetid stools. These symptoms becoming worse, they were carried to the hospital. Coldness and livid colour of the limbs, a dreadful delirium, and acute pains, accompanied them to the last moment. One of them sunk a few hours after his admission into the hospital; the three others had the same fate in the course of the night. On opening their dead bodies, the stomach and intestines displayed large spots of inflammation and gangrene; and putrefaction seemed advancing very rapidly.

AGARICUS MINERALIS, the *mountain milk*, or *mountain meal* of the Germans, is one of the purest of the native carbonates of lime, found chiefly in the clefts of rocks, and at the bottom of some lakes, in a loose or semi-indurated form. It has been used internally in hæmorrhages, strangury, gravel, and dysenteries; and externally as an application to old ulcers, and weak and watery eyes.

M. Fabroni calls by the name of *mineral agaric*, or *fossil meal*, a stone of a loose consistence found in Tuscany in considerable abundance, of which bricks may be made, either with or without the addition of a twentieth part of argil, so light as to float in water; and which he supposes the ancients used for making their floating bricks. This, however, is very different from the preceding, not being even of the calcareous genus, since it appears, on analysis, to consist of silex 55 parts, magnesia 15, water 14, argil 12, lime 3, iron 1. Kirwan calls it *argillo-murite*.

AGATE. A mineral, whose basis is calcedony, blended with variable proportions of jasper, amethyst, quartz, opal, heliotrope, and cornelian. *Ribbon agate* consists of alternate and parallel layers of calcedony with jasper, or quartz, or amethyst. The most beautiful comes from Siberia and Saxony. It occurs in porphyry and gneiss.—*Brecciated agate;* a base of amethyst, containing fragments of ribbon agate, constitute this beautiful variety. It is of Saxon origin.—*Fortification agate*, is found in nodules of various imitative shapes, imbedded in amygdaloid. This occurs at Oberstein on the Rhine, and in Scotland. On cutting it across, and polishing it, the interior zig-zag parallel lines bear a considerable resemblance to the plan of a modern fortification. In the very centre, quartz and amethyst are seen in a splintery mass, surrounded by the jasper and calcedony.—*Mocha stone*. Translucent calcedony, containing dark outlines of arborization, like vegetable filaments, is called Mocha stone, from the place in Arabia where it is chiefly found. These curious appearances were ascribed to deposits of iron or manganese, but more lately they have been thought to arise from mineralized plants of the cryptogamous class.—*Moss agate*, is a calcedony with variously coloured ramifications of a vegetable form, occasionally traversed with irregular veins of red jasper. Dr. M'Culloch has recently detected, what Daubenton merely conjectured, in mocha and moss agates, aquatic confervæ, unaltered both in colour and form, and also coated with iron oxide. Mosses and lichens have also been observed, along with chlorite, in vegetations. An onyx agate set in a ring, belonging to the Earl of Powis, contains the chrysalis of a moth. Agate is found in most countries, chiefly in trap rocks, and serpentine. Hollow nodules of agate, called *geodes*, present interiorly crystals of quartz, colourless or amethystine, having occasionally scattered crystals of stilbite, chabasie, and capillary mesotype. These geodes are very common. Bitumen has been found by M. Patrin in the inside of some of them, among the hills of Dauria, on the right bank of the Chilca. The small geodes of volcanic districts contain water occasionally in their cavities. These are chiefly found in insulated blocks of a lava having an earthy fracture. When they are cracked, the liquid escapes by evaporation: it is easily restored by plunging them for a little in hot water. Agates are artificially coloured by immersion in metallic solutions. Agates were more in demand formerly than at present. They were cut into cups and plates for boxes; and also into cutlass and sabre handles. They are still cut and polished on a considerable scale and at a moderate price, at Oberstein. The surface to be polished is first coarsely ground by large millstones of a hard reddish sandstone, moved by water. The polish is afterwards given on a wheel of soft wood, moistened and imbued with a fine powder of a hard red *tripoli* found in the neighbourhood. M. Faujas thinks that this *tripoli* is produced by the decomposition of the porphyrated rock that serves as a gangue to the agates. The ancients employed agates for making cameos. (See CALCEDONY.) Agate mortars are valued by analytical chemists, for reducing hard minerals to an impalpable powder. For some interesting optical properties of agates, see LIGHT.

The oriental agate is almost transparent, and of a vitreous appearance. The occidental is of various colours, and often veined with quartz or jasper. It is mostly found in small pieces covered with a crust, and often running in veins through rocks like flint and petrosilex, from which it does not seem to differ greatly. Agates are most prized, when the internal figure nearly resembles some animal or plant.

AGGREGATE. When bodies of the same kind are united, the only consequence is, that one larger body is produced. In this case, the united mass is called an aggregate, and does not differ in its chemical properties from the bodies from which it was originally made. Elementary writers call the smallest parts into which an aggregate can be divided without destroying its chemical properties, integrant parts. Thus the integrant parts of common salt are the smallest parts which can be conceived to remain without change; and beyond these, any further subdivision cannot be made without developing the component parts, namely, the alkali and the acid; which are still further resolvable into their constituent principles.

AGRICULTURE, considered as a department of chemistry, is a subject of vast importance, but hitherto much neglected. When we consider that every change in the arrangements of matter connected with the growth and nourishment of plants; the comparative values of their produce as food; the composition and constitution of soils; and the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation, we shall not hesitate to assign to chemical agriculture a high place among the studies of man. If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of attaining this object is by determining the causes of its sterility, which must necessarily depend upon some defect in the constitution of the soil, which may be easily discovered by chemical analysis. Some lands of good apparent texture are yet eminently barren; and common observation and common practice afford no means of ascertaining the cause, or of removing the effect. The application of chemical tests in such cases is obvious; for the soil must contain some noxious principle which may be easily discovered, and probably easily destroyed. Are any of the salts of iron present? They may be decomposed by lime. Is there an excess of siliceous sand? The system of improvement must depend on the application of clay and calcareous matter. Is there a defect of calcareous matter? The remedy is obvious. Is an excess of vegetable matter indicated? It may be removed by liming, paring, and burning. Is there a deficiency of vegetable matter? It is to be supplied by manure. Peat earth is a manure; but there are some varieties of peats which contain so large a quantity of ferruginous matter as to be absolutely poisonous to plants. There has been no question on which more difference of opinion has existed, than that of the state in which manure ought to be ploughed into land; whether recent, or when it has gone through the process of fermentation. But whoever will refer to the simplest principles of chemistry, cannot entertain a doubt on the subject. As soon as dung begins to decompose, it throws off its volatile parts, which are the most valuable and most efficient. Dung which has fermented so as to become a mere soft cohesive mass, has generally lost from one-third to one-half of its most useful constituent elements. See the articles ANALYSIS, MANURE, SOILS, VEGETATION, and Sir H. Davy's Agricult. Chem.

AIR was, till lately, used as the generic name for such invisible and exceedingly rare fluids as possess a very high degree of elasticity, and are not condensable into the liquid state by any degree of cold hitherto produced; but as this term is commonly employed to signify that compound of aëriform fluids which constitutes our atmosphere, it has been deemed advisable to restrict it to this signification, and to employ as the generic term the word GAS, (which see), for the different kinds of air, except what relates to our atmospheric compound.

AIR (ATMOSPHERICAL or COMMON). The immense mass of permanently elastic fluid which surrounds the globe we inhabit, must consist of a general assemblage of every kind of air which can be formed by the various bodies that compose its surface. Most of these, however, are absorbed by water; a number of them are decomposed by combination with each other; and some of them are seldom disengaged in considerable quantities by the processes of nature. Hence it is that the lower atmosphere consists chiefly of oxygen and nitrogen, together with moisture and the occasional vapours or exhalations of bodies. The upper atmosphere seems to be composed of a large proportion of hydrogen, a fluid of so much less specific gravity than any other, that it must naturally ascend to the highest place, where, being occasionally set on fire by electricity, it appears to be the cause of the aurora borealis and fire balls. It may easily be understood, that this will only happen on the confines of the respective masses of common atmospherical air, and of the inflammable air; that the combustion will extend progressively, though rapidly, in flashings from the place where it commences; and that when by any means a stream of inflammable air, in its progress toward the upper atmosphere, is set on fire at one end, its ignition may be much more rapid than what happens higher up, where oxygen is wanting, and at the same time more definite in its figure and progression, so as to form the appearance of a fire ball.

To the above speculations, it may probably be objected, that the air on the summit of Mont Blanc, and that brought down from still greater heights by M. Gay Lussac, in an aerostatic machine, gave, on analysis, no product of hydrogen. But the lowest estimate of the height of luminous meteors, is prodigiously greater than the highest elevations to which man has reached.—See COMBUSTION.

That the air of the atmosphere is so transparent as to be invisible, except by the blue colour it reflects when in very large masses, as is seen in the sky or region above us, or in viewing extensive landscapes; that it is without smell, except that of electricity, which it sometimes very manifestly exhibits; altogether without taste, and impalpable; not condensable by any degree of cold into the dense fluid state, though easily changing its dimensions with its temperature; that it gravitates and is highly elastic; are among the numerous observations and discoveries which do honour to the sagacity of the philosophers of the seventeenth century. They likewise knew that this fluid is indispensably necessary to combustion; but no one, except the great, though neglected, John Mayow, appears to have formed any proper notion of its manner of acting in that process.

The air of the atmosphere, like other fluids, appears to be capable of holding bodies in solution. It takes up water in considerable quantities, with a diminution of its own specific gravity; from which circumstance, as well as from the consideration that water rises very plentifully in the vaporous state *in vacuo*, it seems probable, that the air suspends vapour, not so much by a real solution, as by keeping its particles asunder, and preventing their condensation. Water likewise dissolves or absorbs air.

Mere heating or cooling does not affect the chemical properties of atmospherical air; but actual combustion, or any process of the same nature, combines its oxygen, and leaves its nitrogen separate. Whenever a process of this kind is carried on in a vessel containing atmospherical air, which is enclosed either by inverting the vessel over mercury, or by stopping its aperture in a proper manner, it is found that the process ceases after a certain time; and that the remaining air (if a combustible body capable of solidifying the oxygen, such as phosphorus, have been employed), has lost about a fifth part of its volume, and is of such a nature as to be incapable of maintaining any combustion for a second time, or of supporting the life of animals. From these experiments it is clear, that one of the following deductions must be true:—1. The combustible body has emitted some principle, which, by combining with the air, has rendered it unfit for the purpose of further combustion; or, 2. It has absorbed part of the air which was fit for that purpose, and has left a residue of a different nature; or, 3. Both events have happened; namely, that the pure part of the air has been absorbed, and a principle has been emitted, which has changed the original properties of the remainder.

The facts must clear up these theories. The first induction cannot be true, because the residual air is not only of less bulk, but of less specific gravity, than before. The air cannot therefore have received so much as it has lost. The second is the doctrine of the philosophers who deny the existence of phlogiston, or a principle of inflammability; and the third must be adopted by those who maintain that such a principle escapes from bodies during combustion. This residue was called phlogisticated air, in consequence of such an opinion.

In the opinion that inflammable air is the phlogiston, it is not necessary to reject the second inference, that the air has been no otherwise changed than by the mere subtraction of one of its principles: for the pure or vital part of the air may unite with inflammable air supposed to exist in a fixed state in the combustible body; and if the product of this union still continues fixed, it is evident, that the residue of the air, after combustion, will be the same as it would have been if the vital part had been absorbed by any other fixed body. Or, if the vital air be absorbed, while inflammable air or phlogiston is disengaged, and unites with the aëriform residue, this residue will not be heavier than before, unless the inflammable air it has gained exceeds in weight the vital air it has lost; and if the inflammable air falls short of that weight, the residue will be lighter.

These theories it was necessary to mention; but it has been sufficiently proved by various experiments, that combustible bodies take oxygen from the atmosphere, and leave nitrogen; and that when these two fluids are again mixed in due proportions, they compose a mixture not differing from atmospherical air.

The respiration of animals produces the same effect on atmospherical air as combustion does, and their constant heat appears to be an effect of the same nature. When an animal is included in a limited quantity of atmospherical air, it dies as soon as the oxygen is consumed; and no other air will maintain animal life but oxygen, or a mixture which contains it. Pure oxygen maintains the life of animals much longer than atmospherical air, bulk for bulk.

It is to be particularly observed, however, that, in many cases of combustion, the oxygen of the air, in combining with the combustible body, produces a compound, not solid or liquid, but aëriform. The residual air will therefore be a mixture of the nitrogen of the atmosphere with the consumed oxygen, converted into another gas. Thus, in burning charcoal, the carbonic acid gas generated, mixes with the residual nitrogen, and makes up exactly, when the effect of heat ceases, the bulk of the original air. The breathing of animals, in like manner, changes the oxygen into carbonic acid gas, without altering the atmospherical volume.

There are many provisions in nature by which the proportion of oxygen in the atmosphere, which is continually consumed in respiration and combustion, is again restored to that fluid. In fact there appears, as far as an estimate can be formed of the great and general operations of nature, to be at least as great an emission of oxygen, as is sufficient to keep the general mass of the atmosphere at the same degree of purity. Thus in volcanic eruptions there seems to be at least as much oxygen emitted or extricated by fire from various minerals, as is sufficient to maintain the combustion, and perhaps even to meliorate the atmosphere. And in the bodies of plants and animals, which appear in a great measure to derive their sustenance and augmentation from the atmosphere and its contents, it is found that a large proportion of nitrogen exists. Most plants emit oxygen in the sunshine, from which it is highly probable that they imbibe and decompose the air of the atmosphere, retaining carbon, and emitting the vital part. Lastly, if to this we add the decomposition of water, there will be numerous occasions in which this fluid will supply us with disengaged oxygen; while, by a very rational supposition, its hydrogen may be considered as having entered into the bodies of plants, for the formation of oils, sugars, mucilages, &c. from which it may be again extricated.

To determine the respirability or purity of air, it is evident that recourse must be had to its comparative efficacy in maintaining combustion, or some other equivalent process. This subject will be considered under the article EUDIOMETER.

From the latest and most accurate experiments, the proportion of oxygen in atmospheric air is by measure about 21 per cent.; and it appears to be very nearly the same whether it be in this country or on the coast of Guinea, on low plains or lofty mountains, or even at the height of 7250 yards above the level of the sea, as ascertained by Gay Lussac in his aërial voyage in September 1805. The remainder of the air is nitrogen, with a small portion of aqueous vapour, amounting to about 1 per cent. in the driest weather, and a still less portion of carbonic acid, not exceeding a thousandth part of the whole.

As oxygen and nitrogen differ in specific gravity in the proportion of 135 to 121, according to Kirwan, and of 139 to 120 according to Davy, it has been presumed, that the oxygen would be more abundant in the lower regions, and the nitrogen in the higher, if they constituted a mere mechanical mixture, which appears contrary to the fact. On the other hand, it has been urged, that they cannot be in the state of chemical combination, because they both retain their distinct properties unaltered, and no change of temperature or density takes place on their union. But perhaps it may be said, that, as they have no repugnance to mix with each other, as oil and water have, the continual agitation to which the atmosphere is exposed, may be sufficient to prevent two fluids, differing not more than oxygen and nitrogen in gravity, from separating by subsidence, though simply mixed. On the contrary, it may be argued, that to say chemical combination cannot take place without producing new properties, which did not exist before in the component parts, is merely begging the question; for though this generally appears to be the case, and often in a very striking manner, yet combination does not always produce a change of properties, as appears in M. Biot's experiments with various substances, of which we may instance water, the refraction of which is precisely the mean of that of the oxygen and hydrogen, which are indisputably combined in it.

To get rid of the difficulty, Mr. Dalton of Manchester framed an ingenious hypothesis, that the particles of different gases neither attract nor repel each other; so that one gas expands by the repulsion of its own particles, without any more interruption from the presence of another gas, than if it were in a vacuum. This would account for the state of atmospheric air, it is true; but it does not agree with certain facts. In the case of the carbonic acid gas in the Grotto del Cano, and over the surface of brewers' vats, why does not this gas expand itself freely upward, if the superincumbent gases do not press upon it? Mr. Dalton himself, too, instances as an argument for his hypothesis, that oxygen and hydrogen gases, when mixed by agitation, do not separate on standing. But why should either oxygen or hydrogen require agitation, to diffuse it through a vacuum, in which, according to Mr. Dalton, it is placed?

The theory of Berthollet appears consistent with all the facts, and sufficient to account for the phenomenon. If two bodies be capable of chemical combination, their particles must have a mutual attraction for each other. This attraction, however, may be so opposed by concomitant circumstances, that it may be diminished in any degree. Thus we know, that the affinity of aggregation may occasion a body to combine slowly with a substance for which it has a powerful affinity, or even entirely prevent its combining with it; the presence of a third substance may equally prevent the combination; and so may the absence of a certain quantity of caloric. But in all these cases the attraction of the particles must subsist, though diminished or counteracted by opposing circumstances. Now we know that oxygen and nitrogen are capable of combination; their particles, therefore, must attract each other; but in the circumstances in which they are placed in our atmosphere, that attraction is prevented from exerting itself to such a degree as to form them into a chemical compound, though it operates with sufficient force to prevent their separating by their difference of specific gravity. Thus the state of the atmosphere is accounted for, and every difficulty obviated, without any new hypothesis.

The exact specific gravity of atmospherical air, compared to that of water, is a very nice and important problem. By reducing to 60° Fahr. and to 30 inches of the barometer, the results obtained with great care by MM. Biot and Arago, the specific gravity of atmospherical air appears to be 0.001220, water being represented by 1.000000. This relation expressed fractionally is $\frac{1}{820}$, or water is 820 times denser than atmospherical air. Mr. Rice, in the 77th and 78th numbers of the Annals of Philosophy, deduces from Sir George Shuckburgh's experiments 0.00120855 for the specific gravity of air. This number gives water to air as 827.437 to 1. If with Mr. Rice we take the cubic inch of water = 252.525 gr. then 100 cubic inches of air by Biot's experiments will weigh 30.808 grains, and by Mr. Rice's estimate 30.519. He considers with Dr. Prout the asmosphere to be a compound of 4 volumes of nitrogen, and 1 of oxygen; the specific gravity of the first being to that of the second as 1.1111 to 0.9722.

Hence

0.8 vol. nitr. sp. gr. 0.001166 = 0.000933
0.2 oxy. 0.001340 = 0.000268

0.001201

The numbers are transposed in the Annals of Philosophy by some mistake.

MM. Biot and Arago found the specific gravity of oxygen to be . . 1.10359
and that of nitrogen, . . 0.96913
air being reckoned, . . . 1.00000
Or compared to water as unity,—
Nitrogen is 0.001182338
Oxygen, 0.001346379
And 0.8 nitrogen =0.00094587
0.2 oxygen =0.00026927
0.00121514

And 0.79 nitrogen =0.000934
0.21 oxygen =0.000283
0.001217

A number which approaches very nearly to the result of experiment. Many analogies, it must be confessed, favour Dr. Prout's proportions; but the greater number of experiments on the composition and density of the atmosphere agree with Biot's results. Nothing can decide these fundamental chemical proportions except a new, elaborate, and most minutely accurate series of experiments. We shall then know whether the atmosphere contains in volume 20 or 21 per cent. of oxygen. See METEOROLOGY and GAS.

ALALITE. See DIOPSIDE.

ALABASTER. Among the stones which are known by the name of marble, and have been distinguished by a considerable variety of denominations by statuaries and others, whose attention is more directed to their external character and appearance than their component parts, alabasters are those which have a greater or less degree of imperfect transparency, a granular texture, are softer, take a duller polish than marble, and are usually of a whiter colour. Some stones, however, of a veined and coloured appearance, have been considered as alabasters, from their possessing the first mentioned criterion; and some transparent and yellow sparry stones have also received this appellation.

Chemists are at present agreed in applying this name only to such opaque, consistent, and semitransparent stones, as are composed of lime united with the sulphuric acid. But the term is much more frequent among masons and statuaries than chemists. Chemists in general confound the alabasters among the selenites, gypsums, or plaster of Paris, more especially when they allude only to the component parts, without having occasion to consider the external appearance, in which only these several compounds differ from each other.

As the semi-opaque appearance and granular texture arise merely from a disturbed or successive crystallization, which would else have formed transparent spars, it is accordingly found, that the calcareous stalactites, or drop-stones, formed by the transition of water through the roofs of caverns in a calcareous soil, do not differ in appearance from the alabaster, most of which is also formed in this manner. But the calcareous stalactites here spoken of consist of calcareous earth and carbonic acid; while the alabaster of the chemists is formed of the same earth and sulphuric acid, as has already been remarked.

ALBIN. A mineral discovered at Monaberg, near Aussig, in Bohemia; and being of an opaque white colour, has been called, by Werner, *Albin*. Aggregated crystalline laminæ constitute massive albin. Small crystals of it in right prisms, whose summits consist of four quadrangular planes, are found sprinkled over mammelated masses in cavities. See ZEOLITE.

ALBITE. A mineral in crystals, frequently, or, almost always, met under the form of *hemitropes*. These hemitropes are formed when two crystals are so joined to each other, that the upper plane of the one is applied upon the inferior plane of the other. See CLEAVELANDITE, which is the name now given to this mineral.

ALBUM GRÆCUM. Innumerable are the instances of fanciful speculation and absurd credulity in the invention and application of subjects in the more ancient materia medica. The white and solid excrement of dogs, which subsist chiefly on bones, was received as a remedy in the medical art, under the name of Album Græcum. It consists, for the most part, of the earth of bones or lime, in combination with phosphoric acid.

ALBUMEN. This substance, which derives its name from the Latin for the white of an egg, in which it exists abundantly, and in its purest natural state, is one of the chief constituent principles of all the animal solids. Beside the white of egg, it abounds in the serum of blood, the vitreous and crystalline humours of the eye, and the fluid of dropsy. Fourcroy claims to himself the honour of having discovered it in the green feculæ of plants in general, particularly in those of the cruciform order, in very young ones, and in the fresh shoots of trees, though Rouelle appears to have detected it there long before. Vauquelin says it exists also in the mineral water of Plombieres.

M. Seguin has found it in remarkable quantity in such vegetables as ferment without yeast, and afford a vinous liquor; and from a series of experiments he infers, that albumen is the true principle of fermentation, and that its action is more powerful in proportion to its solubility, three different degrees of which he found it to possess.

The chief characteristic of albumen is its coagulability by the action of heat. If the white of an egg be exposed to a heat of about 134° F. white fibres begin to appear in it, and at 160° it coagulates into a solid mass. In a heat not exceeding 212° it dries, shrinks, and assumes the appearance of horn. It is soluble in cold water before it has been coagulated, but not after; and when diluted with a very large portion, it does not coagulate easily. Pure alkalis dissolve it, even after coagulation. It is precipitated by muriate of mercury, nitro-muriate of tin, acetate of lead, nitrate of silver, muriate of gold, infusion of galls, and tannin. The acids and metallic oxides coagulate albumen. On the addition of concentrated sulphuric acid, it becomes black, and exhales a nauseous smell. Strong muriatic acid gives a violet tinge to the coagulum, and at length becomes saturated with ammonia. Nitric acid, at 70° F. disengages from it abundance of azotic gas; and if the heat be increased, prussic acid is formed, after which carbonic acid and carburetted hydrogen are evolved, and the residue consists of water containing a little oxalic acid, and covered with a lemon-coloured fat oil. If dry potash or soda be triturated with albumen, either liquid or solid, ammoniacal gas is evolved, and the calcination of the residuum yields an alkaline prussiate.

On exposure to the atmosphere in a moist state, albumen passes at once to the state of putrefaction.

Solid albumen may be obtained by agitating white of egg with ten or twelve times its weight of alcohol. This seizes the water which held the albumen in solution; and this substance is precipitated under the form of white flocks or filaments, which cohesive attraction renders insoluble, and which consequently may be freely washed with water. Albumen thus obtained is like fibrine, solid, white, insipid, inodorous, denser than water, and without action on vegetable colours. It dissolves in potash and soda more easily than fibrine; but in acetic acid and ammonia with more difficulty. When these two animal principles are separately dissolved in potash, muriatic acid added to the albuminous does not disturb the solution, but it produces a cloud in the other.

Fourcroy and several other chemists have ascribed the characteristic coagulation of albumen by heat to its oxygenation. But cohesive attraction is the real cause of the phenomenon. In proportion as the temperature rises, the particles of water and albumen recede from each other, their affinity diminishes, and then the albumen precipitates. However, by uniting albumen with a large quantity of water, we diminish its coagulating property to such a degree, that heat renders the solution merely opalescent. A new-laid egg yields a soft coagulum by boiling; but when, by keeping, a portion of the water has transuded so as to leave a void space within the shell, the concentrated albumen affords a firm coagulum. An *analogous phenomenon* is exhibited by acetate of alumina, a solution of which, being heated, gives a precipitate in flakes, which redissolve as the caloric which separated the particles of acid and base escapes, or as the temperature falls. A solution containing $\frac{1}{10}$ of dry albumen forms by heat a solid *coagulum;* but when it contains only $\frac{1}{15}$, it gives a glairy liquid. One thousandth part, however, on applying heat, occasions opalescence. Putrid white of egg, and the *pus* of ulcers, have a similar smell. According to Dr. Bostock, a drop of a saturated solution of corrosive sublimate let fall into water containing $\frac{1}{2000}$ of albumen, occasions a milkiness and curdy precipitate. On adding a slight excess of the mercurial solution to the albuminous liquid, and applying heat, the precipitate which falls, being dried, contains in every 7 parts, 5 of albumen. Hence that salt is the most delicate test of this animal product. The yellow pitchy precipitate occasioned by tannin is brittle when dried, and not liable to putrefaction. But tannin, or infusion of galls, is a much nicer test of gelatin than of albumen.

The cohesive attraction of coagulated albumen makes it resist putrefaction. In this state it may be kept for weeks under water without suffering change. By long digestion in weak nitric acid, albumen seems convertible into gelatin. By the analysis of Gay Lussac and Thenard, 100 parts of albumen are formed of 52.883 carbon, 23.872 oxygen, 7.540 hydrogen, 15.705 nitrogen; or in other terms, of 52.883 carbon, 27.127 oxygen and hydrogen, in the proportions for constituting water, 15.705 nitrogen, and 4.285 hydrogen in excess. The negative pole of a voltaic pile in high activity coagulates albumen; but if the pile be feeble, coagulation goes on only at the positive surface. Albumen, in such a state of concentration as it exists in serum of blood, can dissolve some metallic oxides, particularly the protoxide of iron. Orfila has found white of egg to be the best antidote to the poisonous effects of corrosive sublimate on the human stomach. As albumen occasions precipitates with the solutions of almost every metallic salt, probably it may act beneficially against other species of mineral poison.

From its coagulability albumen is of great use in clarifying liquids. See CLARIFICATION.

It is likewise remarkable for the property of rendering leather supple, for which purpose a solution of whites of eggs in water is used by leather-dressers; and hence Dr. Lobb, of Yeovil, in Somersetshire, was induced to employ this solution in cases of contraction and rigidity of the tendons, and derived from it apparent success.

Whites of eggs beaten in a basin with a lump of alum, till they coagulate, form the *alum curd* of Riverius, or *alum cataplasm* of the London Pharmacopœia, used to remove inflammations of the eyes.

ALBURNUM. The interior white bark of trees.

ALCARRAZAS. A species of porous pottery made in Spain, for the purpose of cooling water by its transudation and copious evaporation from the sides of the vessel. M. Darcet gives the following as the analysis of the clay which is employed for the purpose: 60 calcareous earth, mixed with alumina and a little peroxide of iron, and 36 of siliceous earth, mixed with a little alumina. In working up the earths with water, a quantity of salt is added, and dried in it. The pieces are only half baked.

ALCHEMY. A title of dignity, given in the dark ages, by the adepts, to the mystical art by which they professed to find the philosopher's stone, that was to transmute base metals into gold, and prepare the elixir of life. Though avarice, fraud, and folly were their motives, yet their experimental researches were instrumental in promoting the progress of chemical discovery. Hence, in particular, metallic pharmacy derived its origin.

ALCOHOL. This term is applied in strictness only to the pure spirit obtainable by distillation and subsequent rectification from all liquids that have undergone vinous fermentation, and from none but such as are susceptible of it. But it is commonly used to signify this spirit more or less imperfectly freed from water, in the state in which it is usually met with in the shops, and in which, as it was first obtained from the juice of the grape, it was long distinguished by the name of spirit of wine. At present it is extracted chiefly from grain or melasses in Europe, and from the juice of the sugar-cane in the West Indies; and in the diluted state in which it commonly occurs in trade, constitutes the basis of the several spirituous liquors called brandy, rum, gin, whisky, and cordials, however variously denominated or disguised.

As we are not able to compound alcohol immediately from its ultimate constituents, we have recourse to the process of fermentation, by which its principles are first extricated from the substances in which they were combined, and then united into a new compound; to distillation, by which this new compound, the alcohol, is separated in a state of dilution with water, and contaminated with essential oil; and to rectification, by which it is ultimately freed from these.

It appears to be essential to the fermentation of alcohol, that the fermenting fluid should contain saccharine matter, which is indispensable to that species of fermentation called vinous. In France, where a great deal of wine is made, particularly at the commencement of the vintage, that is too weak to be a saleable commodity, it is a common practice to subject this wine to distillation, in order to draw off the spirit; and as the essential oil that rises in this process is of a more pleasant flavour than that of malt or melasses, the French brandies are preferred to any other; though even in the flavour of these there is a difference, according to the wine from which they are produced. In the West Indies a spirit is obtained from the juice of the sugar-cane, which is highly impregnated with its essential oil, and well known by the name of *rum*. The distillers in this country use grain, or melasses, whence they distinguish the products by the name of *malt spirits* and *melasses spirits*. It is said that a very good spirit may be extracted from the husks of gooseberries or currants, after wine has been made from them.

As the process of malting developes the saccharine principle of grain, it would appear to render it fitter for the purpose; though it is the common practice to use about six parts of raw grain with one of malt. For this two reasons may be assigned: by using raw grain the expense of malting is saved, as well as the duty on malt; and the process of malting requires some nicety of attention, since, if it be carried too far, part of the saccharine matter is lost, and if it be stopped too soon, this matter will not be wholly developed. Besides, if the malt be dried too quickly, or by an unequal heat, the spirit it yields will be less in quantity, and more unpleasant in flavour. Another object of economical consideration is, what grain will afford the most spirit in proportion to its price, as well as the best in quality. Barley appears to produce less spirit than wheat; and if three parts of raw wheat be mixed with one of malted barley, the produce is said to be particularly fine. This is the practice of the distillers in Holland for producing a spirit of the finest quality; but in England they are expressly prohibited from using more than one part of wheat to two of other grain. Rye, however, affords still more spirit than wheat.

The practice with the distillers in Scotland is to use one part of malted with from four to nine parts of unmalted grain. This mixture yields an equal quantity of spirit, and at a much cheaper rate than when the former proportions are taken.

Whatever be the grain employed, it must be coarsely ground, and then mixed carefully with a little cold water, to prevent its running into lumps; water about 140° F. may then be added, till it is sufficiently mashed; and to the drained off wort, yeast is added. The wort is then to be allowed to ferment in a covered vessel, to which, however, the air can have access. Attention must be paid to the temperature: for if it exceed 87° F. the fermentation will be too rapid; if it be below 60°, the fermentation will cease. The mean between these will generally be found most favourable. In this country it is the more common practice to mash the grain as for brewing malt liquors, and boil the wort. But in whichever way it be prepared, or if the *wash* (so the liquor intended for distillation is called) be made from melasses and water, due attention must be paid to the fermentation, that it be continued till the liquor grows fine, and pungent to the taste, which will generally be about the third day, but not so long as to permit the acetous fermentation to commence.

In this state the wash is to be committed to the still, of which, including the head, it should occupy at least three-fourths; and distilled with a gentle heat as long as any spirit comes over, which will be till about half the wash is consumed. The more slowly the distillation is conducted, the less will the product be contaminated with essential oil, and the less danger will there be of empyreuma. A great saving of time and fuel, however, may be obtained by making the still very broad and shallow, and contriving a free exit for the steam. This has been carried to such a pitch in Scotland, that a still measuring 43 gallons, and containing 16 gallons of wash, has been charged and worked no less than four hundred and eighty times in the space of twenty-four hours. This would be incredible, were it not established by unquestionable evidence. See LABORATORY, article STILL.

The above wonderful rapidity of distillation has now ceased since the excise duties have been levied on the quantity of spirit produced, and not, as formerly, by the size of the still. Hence, too, the spirit is probably improved in flavour.

The first product, technically termed *low wine*, is again to be subjected to distillation, the latter portions of what comes over, called *feints*, being set apart to be put into the wash-still at some future operation. Thus a large portion of the watery part is left behind. This second product, termed *raw spirit*, being distilled again, is called *rectified spirit*. It is calculated, that a hundred gallons of malt or corn wash will not produce above twenty of spirit, containing 60 parts of alcohol to 50 of water: the same of cyder wash, 15 gallons; and of melasses wash, 22 gallons. The most spirituous wines of France, those of Languedoc, Guienne, and Rousillon, yield, according to Chaptal, from 20 to 25 gallons of excellent brandy from 100; but those of Burgundy and Champagne much less. Brisk wines containing much carbonic acid, from the fermentation having been stopped at an early period, yield the least spirit.

The spirit thus obtained ought to be colourless, and free from any disagreeable flavour; and in this state it is fittest for pharmaceutical purposes, or the extraction of tinctures. But for ordinary sale something more is required. The brandy of France, which is most in esteem here, though perfectly colourless when first made, and often preserved so for use in that country, by being kept in glass or stone bottles, is put into new oak casks for exportation, whence it soon acquires an amber colour, a peculiar flavour, and something like an unctuosity of consistence. As it is not only prized for these qualities, but they are commonly deemed essential to it, the English distiller imitates by design these accidental qualities. The most obvious and natural method of doing this would be by impregnating a pure spirit with the extractive, resinous, and colouring matter of oak shavings; but other modes have been contrived. The dulcified spirit of nitre, as it is called, is commonly used to give the flavour; and catechu, or burnt sugar, to impart the desired colour. A French writer has recommended three ounces and a half of finely powdered charcoal, and four ounces and a half of ground rice, to be digested for a fortnight in a quart of malt spirit.

The finest gin is said to be made in Holland, from a spirit drawn from wheat mixed with a third or fourth part of malted barley, and twice rectified over juniper berries; but in general rye meal is used instead of wheat. They pay so much regard to the water employed, that many send vessels to fetch it on purpose from the Meuse; but all use the softest and clearest river water they can get. In England it is the common practice to add oil of turpentine, in the proportion of two ounces to ten gallons of raw spirit, with three handfuls of bay salt, and drawn off till the feints begin to rise.

But corn or melasses spirit is flavoured likewise by a variety of aromatics, with or without sugar, to please different palates; all of which are included under the general technical term of *compounds* or *cordials*.

Other articles have been employed, though not generally, for the fabrication of spirit, as carrots and potatos; and we are lately informed by Professor Proust, that from the fruit of the carob tree he has obtained good brandy in the proportion of a pint from five pounds of the dried fruit.

To obtain pure alcohol, different processes have been recommended; but the purest rectified spirit obtained as above described, being that which is least contaminated with foreign matter, should be employed. Rouelle recommends to draw off half the spirit in a water bath; to rectify this twice more, drawing off two-thirds each time; to add water to this alcohol, which will turn it milky by separating the essential oil remaining in it; to distil the spirit from this water; and finally rectify it by one more distillation.

Baumé sets apart the first running, when about a fourth is come over, and continues the distillation till he has drawn off about as much more, or till the liquor runs off milky. The last running he puts into the still again, and mixes the first half of what comes over with the preceding first product. This process is again repeated, and all the first products being mixed together, are distilled afresh. When about half the liquor is come over, this is to be set apart as pure alcohol.

Alcohol in this state, however, is not so pure as when, to use the language of the old chemists, it has been *dephlegmated*, or still further freed from water, by means of some alkaline salt. Boerhaave recommended, for this purpose, the muriate of soda, deprived of its water of crystallization by heat, and added hot to the spirit. But the subcarbonate of potash is preferable. About a third of the weight of the alcohol should be added to it in a glass vessel, well shaken, and then suffered to subside. The salt will be moistened by the water absorbed from the alcohol; which being decanted, more of the salt is to be added, and this is to be continued till the salt falls dry to the bottom of the vessel. The alcohol in this state will be reddened by a portion of the pure potash, which it will hold in solution, from which it must be freed by distillation in a water bath. Dry muriate of lime may be substituted advantageously for the alkali.

By enclosing dilute alcohol in a bladder, the water exudes, and the spirit is concentrated. Soemmering says, that if we put alcohol of a moderate strength into an ox's bladder, or a calf's, coated with isinglass, and suspend it over a sand bath, in a few days the alcohol will lose one-fourth of its bulk, and be found quite free from water, or become *absolute alcohol. Gior. di Fisica*, vii. 239.

As alcohol is much lighter than water, its specific gravity is adopted as the test of its purity. Fourcroy considers it as rectified to the highest point when its specific gravity is 829, that of water being 1000; and perhaps this is nearly as far as it can be carried by the process of Rouelle or Baumé simply. M. Bories found the first measure that came over from twenty of spirit at 836 to be 820, at the temperature of 71° F. Sir Charles Blagden, by the addition of alkali, brought it to 813, at 60° F. Chaussier professes to have reduced it to 798; but he gives 998.35 as the specific gravity of water. Lowitz asserts that he has obtained it at 791, by adding as much alkali as nearly to absorb the spirit; but the temperature is not indicated. In the shops it is about 835 or 840: according to the London College it should be 815.

It is by no means an easy undertaking to determine the strength or relative value of spirits, even with sufficient accuracy for commercial purposes. The following requisites must be obtained before this can be well done: the specific gravity of a certain number of mixtures of alcohol and water must be taken so near each other, as that the intermediate specific gravities may not perceptibly differ from those deduced from the supposition of a mere mixture of the fluids; the expansions or variations of specific gravity in these mixtures must be determined at different temperatures; some easy method must be contrived of determining the presence and quantity of saccharine or oleaginous matter which the spirit may hold in solution, and the effect of such solution on the specific gravity; and lastly, the specific gravity of the fluid must be ascertained by a proper floating instrument with a graduated stem, or set of weights; or, which may be more convenient, with both.

The strength of brandies in commerce is judged by the phial, or by burning. The phial proof consists in agitating the spirit in a bottle, and observing the form and magnitude of the bubbles that collect round the edge of the liquor, technically termed the *bead*, which are larger the stronger the spirit. These probably depend on the solution of resinous matter from the cask, which is taken up in greater quantities, the stronger the spirit. It is not difficult, however, to produce this appearance by various simple additions to weak spirit. The proof by burning is also fallacious; because the magnitude of the flame, and quantity of residue, in the same spirit, vary greatly with the form of the vessel it is burned in. If the vessel be kept cool, or suffered to become hot, if it be deeper or shallower, the results will not be the same in each case. It does not follow, however, but that manufacturers and others, may in many instances receive considerable information from these signs, in circumstances exactly alike, and in the course of operations wherein it would be inconvenient to recur continually to experiments of specific gravity.

The importance of this object, as well for the purposes of revenue as of commerce, induced the British government to employ Dr. Blagden, now Sir Charles, to institute a very minute and accurate series of experiments. These may be considered as fundamental results; for which reason, I shall give a summary of them in this place, from the Philosophical Transactions for 1790.

The first object to which the experiments were directed, was to ascertain the quantity and law resulting from the mutual penetration of water and spirit.

All bodies in general expand by heat; but the quantity of this expansion, as well as the law of its progression, is probably not the same in any two substances. In water and spirit they are remarkably different. The whole expansion of pure spirit from 30° to 100° of Fahrenheit's thermometer is not less than 1-25th of its whole bulk at 30°; whereas that of water, in the same interval, is only 1-145 of its bulk. The laws of their expansion are still more different than the quantities. If the expansion of quicksilver be, as usual, taken for the standard, (our thermometers being constructed with that fluid), the expansion of spirit is, indeed, progressively increasing with respect to that standard, but not much so within the abovementioned interval; while water kept from freezing to 30°, which may easily be done, will absolutely contract as it is heated for ten or more degrees, that is to 40° or 42° of the thermometer, and will then begin to expand as its heat is augmented, at first slowly, and afterward gradually more rapidly, so as to observe upon the whole a very increasing progression. Now, mixtures of these two substances will, as may be supposed, approach to the less or the greater of these progressions, according as they are compounded of more spirit or more water, while their total expansion will be greater, according as more spirit enters into their composition; but the exact quantity of the expansion, as well as law of the progression, in all of them, can be determined only by trials. These were, therefore, the two other principal objects to be ascertained by experiment.

The person engaged to make these experiments was Dr. Dollfuss, an ingenious Swiss gentleman then in London, who had distinguished himself by several publications on chemical subjects. As he could not conveniently get the quantity of spirit he wanted lighter than 825, at 60° F., he fixed upon this strength as the standard for alcohol.

These experiments of Dr. Dollfuss were repeated by Mr. Gilpin, clerk of the Royal Society; and as the deductions in this account will be taken chiefly from that last set of experiments, it is proper here to describe minutely the method observed by Mr. Gilpin in his operation. This naturally resolves itself into two parts: the way of making the mixtures, and the way of ascertaining their specific gravity.

1. The mixtures are made by weight, as the only accurate method of fixing the proportions. In fluids of such very unequal expansions by heat as water and alcohol, if measures had been employed, increasing or decreasing in regular proportions to each other, the proportions of the masses would have been sensibly irregular: now the latter was the object in view, namely, to determine the real quantity of spirit in any given mixture, abstracting the consideration of its temperature. Besides, if the proportions had been taken by measure, a different mixture should have been made at every different degree of heat. But the principal consideration was, that with a very nice balance, such as was employed on this occasion, quantities can be determined to much greater exactness by weight than by any practicable way of measurement. The proportions were therefore always taken by weight. A phial being provided of such a size as that it should be nearly full with the mixture, was made perfectly clean and dry, and being counterpoised, as much of the pure spirit as appeared necessary was poured into it. The weight of this spirit was then ascertained, and the weight of distilled water required to make a mixture of the intended proportions was calculated. This quantity of water was then added, with all the necessary care, the last portions being put in by means of a well-known instrument, which is composed of a small dish terminating in a tube drawn to a fine point: the top of the dish being covered with the thumb, the liquor in it is prevented from running out through the tube by the pressure of the atmosphere, but instantly begins to issue by drops, or a very small stream, upon raising the thumb. Water being thus introduced into the phial, till it exactly counterpoised the weight, which having been previously computed, was put into the opposite scale, the phial was shaken, and then well stopped with its glass stopple, over which leather was tied very tight to prevent evaporation. No mixture was used till it had remained in the phial at least a month, for the full penetration to have taken place; and it was always well shaken before it was poured out to have its specific gravity tried.

2. There are two common methods of taking the specific gravity of fluids; one by finding the weight which a solid body loses by being immersed in them; the other, by filling a convenient vessel with them, and ascertaining the increase of weight it acquires. In both cases a standard must have been previously taken, which is usually distilled water; namely, in the first method, by finding the weight lost by the solid body in the water; and in the second method, the weight of the vessel filled with water. The latter was preferred, for the following reasons:—

When a ball of glass, which is the properest kind of solid body, is weighed in any spirituous or watery fluid, the adhesion of the fluid occasions some inaccuracy, and renders the balance comparatively sluggish. To what degree this effect proceeds is uncertain; but from some experiments made by Mr. Gilpin with that view, it appears to be very sensible. Moreover, in this method a large surface must be exposed to the air during the operation of weighing, which, especially in the higher temperatures, would give occasion to such an evaporation as to alter essentially the strength of the mixture. It seemed also as if the temperature of the fluid under trial could be determined more exactly in the method of filling a vessel, than in the other: for the fluid cannot well be stirred while the ball to be weighed remains immersed in it; and as some time must necessarily be spent in the weighing, the change of heat which takes place during that period will be unequal through the mass, and may occasion a sensible error. It is true, on the other hand, that in the method of filling a vessel, the temperature could not be ascertained with the utmost precision, because the neck of the vessel employed, containing about ten grains, was filled up to the mark with spirit not exactly of the same temperature, as will be explained presently: but this error, it is supposed, would by no means equal the other, and the utmost quantity of it may be estimated very nearly. Finally, it was much easier to bring the fluid to any given temperature when it was in a vessel to be weighed, than when it was to have a solid body weighed in it; because in the former case the quantity was smaller, and the vessel containing it more manageable, being readily heated with the hand or warm water, and cooled with cold water: and the very circumstance, that so much of the fluid was not required, proved a material convenience. The particular disadvantage in the method of weighing in a vessel, is the difficulty of filling it with extreme accuracy; but when the vessel is judiciously and neatly marked, the error of filling will, with due care, be exceedingly minute. By several repetitions of the same experiments, Mr. Gilpin seemed to bring it within the 1-15000th part of the whole weight.

The above-mentioned considerations induced Dr. Blagden, as well as the gentlemen employed in the experiments, to give the preference to weighing the fluid itself; and that was accordingly the method practised both by Dr. Dollfuss and Mr. Gilpin in their operations.

The vessel chosen as most convenient for the purpose was a hollow glass ball, terminating in a neck of small bore. That which Dr. Dollfuss used held 5800 grains of distilled water; but as the balance was so extremely accurate, it was thought expedient, upon Mr. Gilpin's repetition of the experiments, to use one of only 2965 grains capacity, as admitting the heat of any fluid contained in it to be more nicely determined. The ball of this vessel, which may be called the weighing bottle, measured about 2.8 inches in diameter, and was spherical, except a slight flattening on the part opposite to the neck, which served as a bottom for it to stand upon. Its neck was formed of a portion of a barometer tube, .25 of an inch in bore, and about 1½ inch long; it was perfectly cylindrical, and, on its outside, very near the middle of its length, a fine circle or ring was cut round it with a diamond, as the mark to which it was to be filled with the liquor. This mark was made by fixing the bottle in a lathe, and turning it round with great care, in contact with the diamond. The glass of this bottle was not very thick; it weighed 916 grains, and with its silver cap 936.

When the specific gravity of any liquor was to be taken by means of this bottle, the liquor was first brought nearly to the required temperature, and the bottle was filled with it up to the beginning of the neck only, that there might be room for shaking it. A very fine and sensible thermometer was then passed through the neck of the bottle into the contained liquor, which showed whether it was above or below the intended temperature. In the former case the bottle was brought into colder air, or even plunged for a moment into cold water; the thermometer in the mean time being frequently put into the contained liquor, till it was found to sink to the right point. In like manner, when the liquor was too cold, the bottle was brought into warmer air, immersed in warm water, or more commonly held between the hands, till upon repeated trials with the thermometer the just temperature was found. It will be understood, that during the course of this heating or cooling, the bottle was very frequently shaken between each immersion of the thermometer; and the top of the neck was kept covered, either with the finger, or a silver cap made on purpose, as constantly as possible. Hot water was used to raise the temperature only in heats of 80° and upwards, inferior heats being obtained by applying the hands to the bottle: when the hot water was employed, the ball of the bottle was plunged into it, and again quickly lifted out, with the necessary shaking interposed, as often as was necessary for communicating the required heat to the liquor; but care was taken to wipe the bottle dry after each immersion, before it was shaken, lest any adhering moisture might by accident get into it. The liquor having by these means been brought to the desired temperature, the next operation was to fill up the bottle exactly to the mark upon the neck, which was done with some of the same liquor, by means of a glass funnel with a very small bore. Mr. Gilpin endeavoured to get that portion of the liquor which was employed for this purpose, pretty nearly to the temperature of the liquor contained in the bottle; but as the whole quantity to be added never exceeded ten grains, a difference of ten degrees in the heat of that small quantity, which is more than it ever amounted to, would have occasioned an error of only 1-30th of a degree in the temperature of the mass. Enough of the liquor was put in to fill the neck rather above the mark, and the superfluous quantity was then absorbed to great nicety, by bringing into contact with it the fine point of a small roll of blotting paper. As the surface of the liquor in the neck would be always concave, the bottom or centre of this concavity was the part made to coincide with the mark round the glass; and in viewing it, care was taken that the near and opposite sides of the mark should appear exactly in the same line, by which means all parallax was avoided. A silver cap, which fitted tight, was then put upon the neck to prevent evaporation; and the whole apparatus was in that state laid in the scale of the balance, to be weighed with all the exactness possible.

The spirit employed by Mr. Gilpin was furnished to him by Dr. Dollfuss, under whose inspection it had been rectified from rum supplied by government. Its specific gravity, at 60 degrees of heat, was .82514. It was first weighed pure, in the above-mentioned bottle, at every five degrees of heat from 30 to 100 inclusively. Then mixtures were formed of it and distilled water, in every proportion, from 1-20th of the water to equal parts of water and spirit; the quantity of water added being successively augmented, in the proportion of five grains to one hundred of the spirit; and these mixtures were also weighed in the bottle, like the pure spirit, at every five degrees of heat. The numbers hence resulting are delivered in the following table; where the first column shows the degrees of heat; the second gives the weight of the pure spirit contained in the bottle at those different degrees; the third gives the weight of a mixture in the proportions of 100 parts by weight of that spirit to 5 of water, and so on successively till the water is to the spirit as 100 to 5. They are the mean of three several experiments at least, as Mr. Gilpin always filled and weighed the bottle over again that number of times, if not oftener. The heat was taken at the even degree, as shown by the thermometer, without any allowance in the first instance, because the coincidence of the mercury with a division can be perceived more accurately than any fraction can be estimated; and the errors of the thermometers, if any, it was supposed would be less upon the grand divisions of 5 degrees than in any others. It must be observed, that Mr. Gilpin used the same mixture throughout all the different temperatures, heating it up from 30° to 100°; hence some small error in its strength may have been occasioned in the higher degrees, by more spirit evaporating than water: but this, it is believed, must have been trifling, and greater inconvenience would probably have resulted from interposing a fresh mixture.

The precise specific gravity of the pure spirit employed was .82514; but to avoid an inconvenient fraction, it is taken, in constructing the table of specific gravities, as .825 only, a proportional deduction being made from all the other numbers. Thus the following table gives the true specific gravity, at the different degrees of heat, of a pure rectified spirit, the specific gravity of which at 60° is .825, together with the specific gravities of different mixtures of it with water, at those different temperatures.

Real Specific Gravities at the different Temperatures.

Heat.	The pure spirit.	100 grains of spirit to 5 gr. of water.	100 grains of spirit to 10 gr. of water.	100 grains of spirit to 15 gr. of water.	100 grains of spirit to 20 gr. of water.	100 grains of spirit to 25 gr. of water.	100 grains of spirit to 30 gr. of water.	100 grains of spirit to 35 gr. of water.	100 grains of spirit to 40 gr. of water.	100 grains of spirit to 45 gr. of water.	100 grains of spirit to 60 gr. of water.
30°	.83896	.84995	.85957	.86825	.87585	.88282	.88921	.89511	.90054	.90558	.91023
35	83672	84769	85729	86587	87357	88059	88701	89294	89839	90345	90811
40	83445	84539	85507	86361	87184	87838	88481	89073	89617	90127	90596
45	83214	84310	85277	86131	86905	87613	88255	88849	89396	89909	90380
50	82977	84076	85042	85902	86676	87384	88030	88626	89174	89684	90160
55	82736	83834	84802	85664	86441	87150	87796	88393	88945	89458	89933
60	82500	83599	84568	85430	86208	86918	87569	88169	88720	89232	89707
65	82262	83362	84334	85193	85976	86686	87337	87938	88490	89006	89479
70	82023	83124	84092	84951	85736	86451	87105	87705	88254	88773	89252
75	81780	82878	83851	84710	85496	86212	86864	87466	88018	88538	89018
80	81530	82631	83603	84467	85248	85966	86622	87228	87776	88301	88781
85	81291	82396	83371	84243	85036	85757	86411	87021	87590	88120	88609
90	81044	82150	83126	84001	84797	85518	86172	86787	87360	87889	88376
95	80794	81900	82877	83753	84550	85272	85928	86542	87114	87654	88146
100	80548	81657	82639	83513	84038	85031	85688	86302	86879	87421	87915

Heat.	100 grains of spirit to 55 gr. of water.	100 grains of spirit to 60 gr. of water.	100 grains of spirit to 65 gr. of water.	100 grains of spirit to 70 gr. of water.	100 grains of spirit to 75 gr. of water.	100 grains of spirit to 80 gr. of water.	100 grains of spirit to 85 gr. of water.	100 grains of spirit to 90 gr. of water.	100 grains of spirit to 95 gr. of water.	100 grains of spirit to 100 gr. of water.
30°	.91449	.91847	.92217	.92563	.92889	.93191	.93474	.93741	.93991	.94222
35	91241	91640	92009	92355	92680	92986	93274	93541	93790	94025
40	91026	91428	91799	92151	92476	92783	93072	93341	93592	93827
45	90812	91211	91584	91937	92264	92570	92859	93131	93382	93621
50	90596	90997	91370	91723	92051	92358	92647	92919	93177	93419
55	90367	90768	91144	91502	91837	92145	92436	92707	92963	93208
60	90144	90549	90927	91287	91622	91933	92225	92499	92758	93002
65	89920	90328	90707	91066	91400	91715	92010	92283	92546	92794
70	89695	90104	90484	90847	91181	91493	91793	92069	92333	92580
75	89464	89872	90252	90617	90952	91270	91569	91849	92111	92364
80	89225	89639	90021	90385	90723	91046	91340	91622	91891	92142
85	89043	89460	89843	90209	90558	90882	91186	91465	91729	91969
90	88817	89230	89617	89988	90342	90668	90967	91248	91511	91751
95	88588	89003	89390	89763	90119	90443	90747	91029	91290	91531
100	88357	88769	89158	89536	89889	90215	90522	90805	91066	91310

Heat.	95 grains of spirit to 100 gr. of water.	90 grains of spirit to 100 gr. of water.	85 grains of spirit to 100 gr. of water.	80 grains of spirit to 100 gr. of water.	75 grains of spirit to 100 gr. of water.	70 grains of spirit to 100 gr. of water.	65 grains of spirit to 100 gr. of water.	60 grains of spirit to 100 gr. of water.	55 grains of spirit to 100 gr. of water.	50 grains of spirit to 100 gr. of water.
30°	.94447	.94675	.94920	.95173	.95429	.95681	.95944	.96209	.96470	.96719
35	94249	94484	94734	94988	95246	95502	95772	96048	96315	96579
40	94058	94295	94547	94802	95060	95328	95602	95879	96159	96434
45	93860	94096	94348	94605	94871	95143	95423	95705	95993	96280
50	93658	93897	94149	94414	94683	94958	95243	95534	95831	96126
55	93452	93696	93048	94213	94486	94767	95057	95357	95662	95966
60	93247	93493	93749	94018	94296	94579	94876	95181	95493	95804
65	93040	93285	93546	93822	94099	94388	94689	95000	95318	95635
70	92828	93076	93337	93616	93898	94193	94500	94813	95139	95469
75	92613	92865	93132	93413	93695	93989	94301	94623	94957	95292
80	92393	92646	92917	93201	93488	93785	94102	94431	94768	95111

Heat.	45 grains of spirit to 100gr. of water.	40 grains of spirit to 100gr. of water.	35 grains of spirit to 100gr. of water.	30 grains of spirit to 100 gr. of water.	25 grains of spirit to 100 gr. of water.	20 grains of spirit to 100 gr. of water.	15 grains of spirit to 100 gr. of water.	10 grains of spirit to 100 gr. of water.	5 grains of spirit to 100 gr. of water.
30°	.96967	.97200	.97418	.97635	.97860	.98108	.98412	.98804	.99334
35	96840	97086	97319	97556	97801	98076	98397	98804	99344
40	96706	96967	97220	97472	97737	98033	98373	98795	99345
45	96563	96840	97110	97384	97666	97980	98338	98774	99338
50	96420	96708	96995	97284	97589	97920	98293	98745	99316
55	96272	96575	96877	97181	97500	97847	98239	98702	99284
60	96122	96437	96752	97074	97410	97771	98176	98654	99244
65	95962	96288	96620	96959	97309	97688	98106	98594	99194
70	95802	96143	96484	96836	97203	97596	98028	98527	99134
75	95638	95987	96344	96708	97086	97495	97943	98454	99066
80	95467	95826	96192	96568	96963	97385	97845	98367	98991

From this table, when the specific gravity of any spirituous liquor is ascertained, it will be easy to find the quantity of rectified spirit of the above-mentioned standard, contained in any given quantity of it, either by weight or measure.

Dr. Blagden concludes this part of the report with observing, that as the experiments were made with pure spirit and water, if any extraneous substances are contained in the liquor to be tried, the specific gravity in the tables will not give exactly the proportions of water and spirit in it. The substances likely to be found in spirituous liquors, where no fraud is suspected, are essential oils, sometimes empyreumatic, mucilaginous, or extractive matter, and perhaps some saccharine matter. The effect of these, in the course of trade, seems to be hardly such as would be worth the cognizance of the excise, nor could it easily be reduced to certain rules. Essential and empyreumatic oils are nearly of the same specific gravity as spirit, in general rather lighter, and therefore, notwithstanding the mutual penetration, will probably make little change in the specific gravity of any spirituous liquor in which they are dissolved. The other substances are all heavier than spirit; the specific gravity of common gum being 1.482, and of sugar 1.606, according to the tables of M. Brisson. The effect of them therefore will be to make spirituous liquors appear less strong than they really are. An idea was once entertained of endeavouring to determine this matter with some precision; and accordingly Dr. Dollfuss evaporated 1000 grains of brandy, and the same quantity of rum, to dryness; the former left a residuum of 40 grains, the latter only of 8½ grains. The 40 grains of residuum from the brandy, dissolved again in a mixture of 100 of spirit, with 50 of water, increased its specific gravity .00041; hence the effect of this extraneous matter upon the specific gravity of the brandy containing it, would be to increase the fifth decimal by six nearly, equal to what would indicate in the above mentioned mixture about one-seventh of a grain of water more than the truth, to 100 of spirit; a quantity much too minute for the consideration of government.

The strength of spirits is determined, according to the existing laws, by Sikes's hydrometer; but as many dealers use Dicas's, I shall describe it here, and the former under DISTILLATION.

It consists of a light copper ball, terminating below with a ballast bottom, and above with a thin stem, divided into ten parts. The upper extremity of the stem is pointed, to receive the little brass poises, or discs, having each a hole in its centre. These poises are numbered 0, 10, 20, 30, &c. up to 350, which is the lightest of the series. The intermediate units are given by the subdivisions on the stem. A graduated ivory scale, with a sliding rule and thermometer, accompanies the hydrometer, to make the correction for temperature. The first thing in using this instrument is to plunge the thermometer into a glass cylinder containing the spirits to be tried. The sliding rule has then the degree of temperature indicated, moved opposite to zero. The hydrometer is now placed in the liquid, and such a poise is put on as to submerge a portion of the stem. The weight, added to the number on the stem, gives a sum, opposite to which on the scale we find a quantity by which the particular spirit may exceed or fall short of proof. Thus, if it mark 20 under proof, it signifies that every 100 gallons of that spirit would require to have 20 gallons of water abstracted from it to bring it up to proof. If it mark 10 over proof, we learn that every 100 gallons contain too little water by 10 gallons. When the thermometric degree of 60° is put opposite to zero, then the weights and value of the spirits have the following relations on the scale.

102.5 denotes 20 under proof
122.0 10
143.5 Proof
167. 10 over proof
193. denotes 20 over proof
221. 30
251. 40
284.5 50
322.5 60
350.5 Alcohol.

There is, besides, an upper line on the scale, which exhibits the relation of spirit to water reckoned unity. Thus, above 10 per cent. over proof in the second line, we find in the upper line 8. From which we learn, that 8 of that spirit by bulk, will take 1 of water to bring it down to proof. At 60° Fahr. I find that 10 over proof on Dicas corresponds to specific gravity - - 0.9085

3½ over proof to 0.9169
Proof - - 0.9218

Now, by Gilpin's tables, this indicates a compound of 100 grains of alcohol 0.825, and 85 grains of water. But by Lowitz's table in Crell's Annals, the above specific gravity corresponds to 48 alcohol of 0.791 at the temperature of 68°, united to 52 of water, and cooled down to 60. Equal weights of that strong alcohol and water, give, at 60°, a specific gravity of 0.9175. By the act of parliament of 1762, the specific gravity of proof was fixed at 0.916. It is at present to water as 12 to 13, or = 0.923. See **Distillation.**

For the following table of the quantity of absolute alcohol, in spirits of different densities, we are indebted to Lowitz.

100 parts		Specific gravity.		100 parts.		Specific gravity.		100 parts.		Specific gravity.	
Alc.	Wat.	At 68°.	At 60°.	Alc.	Wat.	At 68°.	At 60°.	Alc.	Wat.	At 68°.	At 60°.
100	0	0.791	0.796	73	27	0.861	0.865	46	54	0.923	0.926
99	1	0.794	0.798	72	28	0.863	0.867	45	55	0.925	0.928
98	2	0.797	0.801	71	29	0.866	0.870	44	56	0.927	0.930
97	3	0.800	0.804	70	30	0.868	0.872	43	57	0.930	0.933
96	4	0.803	0.807	69	31	0.870	0.874	42	58	0.932	0.935
95	5	0.805	0.809	68	32	0.872	0.878	41	59	0.934	0.937
94	6	0.808	0.812	67	33	0.875	0.879	40	60	0.936	0.939
93	7	0.811	0.815	66	34	0.877	0.881	39	61	0.938	0.941
92	8	0.813	0.817	65	35	0.880	0.883	38	62	0.940	0.943
91	9	0.816	0.820	64	36	0.882	0.886	37	63	0.942	0.945
90	10	0.818	0.822	63	37	0.885	0.889	36	64	0.944	0.947
89	11	0.821	0.825	62	38	0.887	0.891	35	65	0.946	0.949
88	12	0.823	0.827	61	39	0.889	0.893	34	66	0.948	0.951
87	13	0.826	0.830	60	40	0.892	0.896	33	67	0.950	0.953
86	14	0.828	0.832	59	41	0.894	0.898	32	68	0.952	0.955
85	15	0.831	0.835	58	42	0.896	0.900	31	69	0.954	0.957
84	16	0.834	0.838	57	43	0.899	0.902	30	70	0.956	0.958
83	17	0.836	0.840	56	44	0.901	0.904	29	71	0.957	0.960
82	18	0.839	0.843	55	45	0.903	0.906	28	72	0.959	0.962
81	19	0.842	0.846	54	46	0.905	0.908	27	73	0.961	0.963
80	20	0.844	0.848	53	47	0.907	0.910	26	74	0.963	0.965
79	21	0.847	0.851	52	48	0.909	0.912	25	75	0.965	0.967
78	22	0.849	0.853	51	49	0.912	0.915	24	76	0.966	0.968
77	23	0.851	0.855	50	50	0.914	0.917	23	77	0.968	0.970
76	24	0.853	0.857	49	51	0.917	0.920	22	78	0.970	0.972
75	25	0.856	0.860	48	52	0.919	0.922	21	79	0.971	0.973
74	26	0.859	0.863	47	53	0.921	0.924	20	80	0.973	0.974

100 parts.		Specific gravity.		100 parts.		Specific gravity.		100 parts.		Specific gravity.	
Alc.	Wat.	At 68°.	At 60°.	Alc.	Wat.	At 68°.	At 60°.	Alc.	Wat.	At 68°.	At 60°.
19	81	0.974	0.975	12	88	0.985	0.986	5	95	0.994	
18	82	0.976	0.977	11	89	0.986	0.987	4	96	0.995	
17	83	0.977	0.978	10	90	0.987	0.988	3	97	0.997	
16	84	0.978	0.979	9	91	0.988	0.989	2	98	0.998	
15	85	0.980	0.981	8	92	0.989	0.990	1	99	0.999	
14	86	0.981	0.982	7	93	0.991	0.991	0	100	1.000	
13	87	0.983	0.984	6	94	0.992	0.992				

The most remarkable characteristic property of alcohol is its solubility or combination in all proportions with water, a property possessed by no other combustible substance, except the acetic spirit obtained by distilling the dry acetates. When it is burned in a chimney which communicates with the worm-pipe of a distilling apparatus, the product, which is condensed, is found to consist of water, which exceeds the spirit in weight about one-eighth part; or more accurately, 100 parts of alcohol, by combustion, yield 136 of water. If alcohol be burned in close vessels with vital air, the product is found to be water and carbonic acid. Whence it is inferred that alcohol consists of hydrogen, united either to carbonic acid, or its acidifiable base; and that the oxygen uniting on the one part with the hydrogen, forms water; and on the other with the base of the carbonic acid, forms that acid.

The most exact experiments on this subject are those recently made by M. de Saussure. The alcohol he used had, at 62.8°, a specific gravity of 0.8302; and by Richter's proportions, it consists of 13.8 water, and 86.2 of absolute alcohol. The vapour of alcohol was made to traverse a narrow porcelain tube ignited, from which the products passed along a glass tube about six feet in length, refrigerated by ice. A little charcoal was deposited in the porcelain, and a trace of oil in the glass tube. The resulting gas being analyzed in an exploding eudiometer, with oxygen, was found to resolve itself into carbonic acid and water. Three volumes of oxygen disappeared for every two volumes of carbonic acid produced; a proportion which obtains in the analysis by oxygenation of olefiant gas. Now, as nothing resulted but a combustible gas of this peculiar constitution, and condensed water equal to $\frac{1222}{4464}$ of the original weight of the alcohol, we may conclude that vapour of water and olefiant gas are the sole constituents of alcohol. Subtracting the 13.8 per cent. of water in the alcohol at the beginning of the experiment, the absolute alcohol of Richter will consist of 13.7 hydrogen, 51.98 carbon, and 34.32 oxygen. Hence M. Gay Lussac infers, that alcohol, in vapour, is composed of one volume olefiant gas, and one volume of the vapour of water, condensed by chemical affinity into one volume.

The sp. gr. of olefiant gas is 0.97804
Of aqueous vapour is 0.62500

Sum = 1.60304
And alcoholic vapour is = 1.6133

These numbers approach nearly to those which would result from two prime equivalents of olefiant gas, combined with one of water; or ultimately, three of hydrogen, two of carbon, and one of oxygen.

The analytical experiments on alcohol were among the most satisfactory of any which I made on vegetable products (see ANALYSIS VEGETABLE); for in repeated verifications the results agreed within one or at most two-hundredths of a grain. Alcohol, specific gravity 0.812, afforded me in 100 parts, 47.85 carbon, 12.24 hydrogen, and 39.91 oxygen; or referring the last two to the composition of water, 44.9 of it, with 7.25 oxygen in excess. Such alcohol would therefore seem to consist nearly of

Carbon	3 atoms	2.250	46.15
Hydrogen	6 . .	0.625	12.82
Oxygen	2 . .	2.000	40.03
		4.875	100.00

Or of 3 atoms of olefiant gas = 2.625
2 water = 2.250;

and in volumes,

3 volumes olefiant gas = 0.9722 × 3 = 2.9166
4 aqueous vapour = 0.625 × 4 = 2.5000.

Thus alcohol 0.812, by the above analysis which I believe merits confidence, differs from M. Gay Lussac's view of absolute alcohol deduced from the experiments of M. de Saussure, in containing an additional volume of aqueous vapour. At the sp. gr. 0.814 alcohol would have exactly this atomic constitution. If the condensation be equal to the whole 3 volumes of olefiant gas, that is if the 7 volumes of constituent gases become 4 of alcohol vapour, we shall have the specific gravity at this strength = 1.3722; the additional volume of aqueous vapour producing necessarily this abatement in the density.

A considerable number of the uses of this fluid as a menstruum will pass under our observation in the various articles of this work. The mutual action between alcohol and acids produces a light, volatile, and inflammable substance, called ether. See ETHER. Pure alkalis unite with spirit of wine, and form alkaline tinctures. Few of the neutral salts unite with this fluid, except such as contain ammonia. The carbonated fixed alkalis are not soluble in it. From the strong attraction which exists between alcohol and water, it unites with this last in saline solutions, and in most cases precipitates the salt. This is a pleasing experiment, which never fails to surprise those who are unacquainted with chemical effects. If, for example, a saturated solution of nitre in water be taken, and an equal quantity of strong spirit of wine be poured upon it, the mixture will constitute a weaker spirit, which is incapable of holding the nitre in solution; it therefore falls to the bottom instantly, in the form of minute crystals.

The degrees of solubility of many neutral salts in alcohol have been ascertained by experiments made by Macquer, of which an account is published in the Memoirs of the Turin Academy. The alcohol he employed was carefully freed from superabundant water by repeated rectifications, without addition of any intermediate substance. The salts employed in his experiments were previously deprived of their water of crystallization by a careful drying. He poured into a matrass, upon each of the salts thus prepared, half an ounce of his alcohol, and set the matrass in a sand bath. When the spirit began to boil, he filtrated it while it was hot, and left it to cool, that he might observe the crystallizations which took place. He then evaporated the spirit, and weighed the saline residuums. He repeated these experiments a second time, with this difference, that instead of evaporating the spirit in which the salt had been digested, he set fire to it in order to examine the phenomena which its flame might exhibit. The principal results of his experiments are subjoined.

Quantity of grains.	*Salts soluble in 200 grains of spirit.*	*Peculiar phenomena of the flame.*
4	Nitrate of potash	Flame larger, higher, more ardent, yellow, and luminous.
5	Muriate of potash	Large, ardent, yellow, and luminous.
0	Sulphate of soda	Considerably red.
15	Nitrate of soda	Yellow, luminous, detonating.
0	Muriate of soda	Larger, more ardent, and reddish.
0	Sulphate of ammonia	None.
108	Nitrate of ammonia	Whiter, more luminous.
24	Muriate of ammonia	None.
288	Nitrate of lime	Larger, more luminous, red, and decrepitating.
288	Muriate of lime	Like that of the calcareous nitre.
84	Nitrate of silver	None.
204	Muriate of mercury	Large, yellow, luminous, and decrepitating.
4	Nitrate of iron	Red and decrepitating.
36	Muriate of iron	More white, luminous, and sparkling.
48	Nitrate of copper	More white, luminous, and green, much smoke. The saline residuum became black and burnt.
48	Muriate of copper	Fine green, white, and red fulgurations.

Macquer accompanies the relation of his experiments with many judicious reflections, not easily capable of abridgment.

The alcohol he employed in the above experiments had a specific gravity of 0.840. In analytical researches, alcohol affords frequently a valuable agent for separating salts from each other. We shall therefore introduce the following additional table, derived chiefly from the experiments of Wenzel:—

100 parts of alcohol dissolve of

	Temp.	
Nitrate of Cobalt, at	54°.5	100 parts
Copper,	54°.5	100
Alumina,	54°.5	100
Lime,		125
Magnesia,	180.5	290
Muriate of Zinc,	54°.5	100
Alumina,	54.5	100
Muriate of Magnesia, at	180.5	547 parts.
Iron,	180.5	100
Copper,	180.5	100
Acetate of Lead,	154°.5	100

At the boiling point, 100 parts of alcohol dissolve of muriate of lime 100 parts.

Nitrate of ammonia, .	89
Corrosive sublimate, .	88.8
Succinic acid, . .	74.0
Acetate of soda, . .	46.5
Nitrate of silver, . .	41.7
Refined sugar, . .	24.6
Boracic acid, . .	20.0
Nitrate of soda, . .	9.6
Acetate of copper, . .	7.5
Muriate of ammonia, .	7.1
Superarseniate of potash, .	3.75
Oxalate of potash, .	2.92
Nitrate of potash, . .	2.08

Muriate of potash, . .	2.08
Arseniate of soda, . .	1.58
Arsenious acid, . .	1.25
Tartrate of potash, . .	0.42

It appears from the experiments of Kirwan, that dried muriate of magnesia dissolves more abundantly in strong than in weak alcohol. 100 parts of specific gravity 0.900, dissolve 21.25; of 0.848, 23.75; of 0.834, 36.25; and of 0.817, 50 parts. The same holds to a more limited extent with acetate of lime, 2.4 grains being soluble in 100 of the first alcohol, and 4.88. in 100 of the last. The other salts which he tried dissolved more sparingly in the stronger than in the weaker alcohol. The temperature of the spirit was generally 60°.

All deliquescent salts are soluble in alcohol. Alcohol holding the strontitic salts in solution, gives a flame of a rich purple. The cupreous salts and boracic acid give a green; the soluble calcareous, a reddish; the barytic, a yellowish. For the effect of other salts on the colour of the flame, see a preceding table.

The alcohol of 0.825 has been subjected to a cold of — 91° without congealing. But Mr. Hutton has given, in the Edinburgh Encyclopædia, article Cold, an account of his having succeeded in solidifying it by a cold of — 110°. The alcohol he employed had a density of 0.798 at 60°. His process has been kept secret. See ACID (SULPHUROUS) for a mode of freezing alcohol by the evaporation of that acid in its liquefied state. The boiling point of alcohol of 0.825 is 176°. Alcohol of 0.810 boils at 173°.5. For the force of its vapour at different temperatures, and its specific heat, see CALORIC, and the Tables of Vapour at the end of the volume.

When potassium and sodium are put in contact with the strongest alcohol, hydrogen is evolved. When chlorine is made to pass through alcohol in a Woolfe's apparatus, there is a mutual action. Water, an oily-looking substance, muriatic acid, a little carbonic acid, and carbonaceous matter, are the products. This oily substance does not redden turnsole, though its analysis by heat shows it to contain muriatic acid. It is white, denser than water, has a cooling taste analogous to mint, and a peculiar, but not ethereous odour. It is very soluble in alcohol, but scarcely in water. The strongest alkalis hardly operate on it.

It was at one time maintained, that alcohol did not exist in wines, but was generated and evolved by the heat of distillation. On this subject M. Gay Lussac made some decisive experiments. He agitated wine with litharge in fine powder, till the liquid became as limpid as water, and then saturated it with subcarbonate of potash. The alcohol immediately separated and floated on the top. He distilled another portion of wine *in vacuo*, at 59° Fahr. a temperature considerably below that of fermentation. Alcohol came over. Mr. Brande proved the same position by saturating wine with subacetate of lead, and adding potash.

MM. Adam and Duportal have substituted for the redistillations used in converting wine or beer into alcohol, a single process of great elegance. From the capital of the still a tube is led into a large copper recipient. This is joined by a second tube to a second recipient, and so on through a series of four vessels, arranged like a Woolfe's apparatus. The last vessel communicates with the worm of the first refrigeratory. This, the body of the still, and the two recipients nearest it, are charged with the wine or fermented liquor. When ebullition takes place in the still, the vapour issuing from it communicates soon the boiling temperature to the liquor in the two recipients, From these the volatilized alcohol will rise and pass into the third vessel, which is empty. After communicating a certain heat to it, a portion of the finer or less condensable spirit will pass into the fourth, and thence, in a little, into the worm of the first refrigeratory. The wine round the worm will likewise acquire heat, but more slowly. The vapour that in that event may pass uncondensed through the first worm, is conducted into a second, surrounded with cold water. Whenever the still is worked off it is replenished by a stopcock from the nearest recipient, which, in its turn, is filled from the second, and the second from the first worm tub. It is evident, from this arrangement, that by keeping the 3d and 4th recipients at a certain temperature, we may cause alcohol, of any degree of lightness, to form directly at the remote extremity of the apparatus. The utmost economy of fuel and time is also secured, and a better flavoured spirit is obtained. The *arrière gout* of bad spirit can scarcely be destroyed by infusion with charcoal and redistillation. In this mode of operating, the taste and smell are excellent, from the first. Several stills on the above principle have been constructed at Glasgow for the West India distillers, and have been found extremely advantageous. The excise laws do not permit their employment in the home trade.

A very ingenious still on the above principles has been recently invented by Mr. J. J. Saintmarc. It has the aspect of a copper tower, containing 9 or 10 stories, each apartment being divided from the one below by a horizontal partition or floor, pierced with openings or vertical pipes, admirably fitted for transferring to the highest stage, a very fine concentrated spirit in an uninterrupted operation. The lowest floor alone is exposed to the naked fire, and the upper ones have their contents heated by the steam which it causes to ascend. The apparatus has an appearance of complication, but I should think it quite simple and satisfactory in its performance. It has been made the subject of a patent.

If sulphur in sublimation meet with the

vapour of alcohol, a very small portion combines with it, which communicates a hydrosulphurous smell to the fluid. The increased surface of the two substances appears to favour the combination. It had been supposed, that this was the only way in which they could be united; but M. Favre has lately asserted, that having digested two drams of flowers of sulphur in an ounce of alcohol, over a gentle fire, not sufficient to make it boil, for twelve hours, he obtained a solution that gave twenty-three grains of precipitate. A similar mixture left to stand for a month in a place exposed to the solar rays, afforded sixteen grains of precipitate; and another, from which the light was excluded, gave thirteen grains. If alcohol be boiled with one-fourth of its weight of sulphur for an hour, and filtered hot, a small quantity of minute crystals will be deposited on cooling; and the clear fluid will assume an opaline hue on being diluted with an equal quantity of water, in which state it will pass the filter, nor will any sediment be deposited for several hours. The alcohol used in the last-mentioned experiment did not exceed .840.

Phosphorus is sparingly soluble in alcohol, but in greater quantity by heat than in cold. The addition of water to this solution affords an opaque milky fluid, which gradually becomes clear by the subsidence of the phosphorus.

Earths seem to have scarcely any action upon alcohol. Quicklime, however, produces some alteration in this fluid, by changing its flavour, and rendering it of a yellow colour. A small portion is probably taken up.

Soaps are dissolved with great facility in alcohol, with which they combine more readily than with water. None of the metals, or their oxides, are acted upon by this fluid. Resins, essential oils, camphor, bitumen, and various other substances, are dissolved with great facility in alcohol, from which they may be precipitated by the addition of water. From its property of dissolving resins, it becomes the menstruum of one class of varnishes. See VARNISH.

Camphor is not only extremely soluble in alcohol, but assists the solution of resins in it. Fixed oils, when rendered drying by metallic oxides, are soluble in it, as well as when combined with alkalis.

Wax, spermaceti, biliary calculi, urea, and all the animal substances of a resinous nature, are soluble in alcohol; but it curdles milk, coagulates albumen, and hardens the muscular fibre and coagulum of the blood.

The uses of alcohol are various. As a solvent of resinous substances and essential oils, it is employed both in pharmacy and by the perfumer. When diluted with an equal quantity of water, constituting what is called proof spirit, it is used for extracting tinctures from vegetable and other substances, the alcohol dissolving the resinous parts, and the water the gummy. From giving a steady heat without smoke when burnt in a lamp, it was formerly much employed to keep water boiling on the tea-table. In thermometers, for measuring great degrees of cold, it is preferable to mercury. It is in common use for preserving many anatomical preparations, and certain subjects of natural history; but to some it is injurious, the molluscæ for instance, the calcareous covering of which it in time corrodes. It is of considerable use too in chemical analysis, as appears under the different articles to which it is applicable.

From the great expansive power of alcohol, it has been made a question, whether it might not be applied with advantage in the working of steam-engines. From a series of experiments made by Betancourt, it appears, that the steam of alcohol has, in all cases of equal temperature, more than double the force of that of water; and that the steam of alcohol at 174° F. is equal to that of water at 212°: thus there is a considerable diminution of the consumption of fuel, and where this is so expensive as to be an object of great importance, by contriving the machinery so as to prevent the alcohol from being lost, it may possibly at some future time be used with advantage, if some other fluid of great expansive power, and inferior price, be not found more economical.

In my experiments on vapours, I found that the latent heat of that of alcohol is less than one half that of water; for which reason the former would serve well for impelling the pistons of steam engines, were it not to act on the metals, which has been surmised.

It was observed at the beginning of this article, that alcohol might be decomposed by transmission through a red-hot tube: it is also decomposable by the strong acids, and thus affords that remarkable product, ETHER, and OLEUM VINI.

ALE. See BEER.

ALEMBIC, *or* STILL. This part of chemical apparatus, used for distilling or separating volatile products, by first raising them by heat, and then condensing them into the liquid state by cold, is of extensive use in a variety of operations. It is described under the article LABORATORY.

ALEMBROTH SALT. Corrosive muriate of mercury is rendered much more soluble in water, by the addition of muriate of ammonia. From this solution crystals are separated by cooling, which were called sal-alembroth by the earlier chemists, and appear to consist of ammonia, muriatic acid, and mercury.

ALGAROTH (POWDER OF). Among the numerous preparations which the alchemical researches into the nature of antimony have afforded, the powder of algaroth is one. When butter of antimony is thrown into water, the greater part of the metallic oxide falls down in the form of a white powder, which is the powder of algaroth. It is violently purgative and emetic in small doses of three or four grains. See ANTIMONY.

ALKAHEST. The pretended universal solvent, or menstruum, of the ancient chemists. Kunckel has very well shown the absurdity of searching for a universal solvent, by asking, "If it dissolve all substances, in what vessels can it be contained?"

ALKALESCENT. Any substance in which alkaline properties are beginning to be developed, or to predominate, is termed alkalescent. The only alkali usually observed to be produced by spontaneous decomposition is ammonia; and from their tendency to produce this, some species of vegetables, particularly the cruciform, are styled alkalescent, as are some animal substances. See FERMENTATION (PUTRID).

ALKALI. A term derived from kali, the Arabic name of a plant, from the ashes of which one species of alkaline substance can be extracted. Alkalis may be defined, those bodies which combine with acids, so as to neutralize or impair their activity, and produce salts. Acidity and alkalinity are therefore two correlative terms of one species of combination. When Lavoisier introduced oxygen as the acidifying principle, Morveau proposed hydrogen as the alkalifying principle, from its being a constituent of volatile alkali or ammonia. But the splendid discovery by Sir H. Davy, of the metallic bases of potash and soda, and of their conversion into alkalis, by combination with oxygen, has banished for ever that hypothetical conceit. It is the mode in which the constituents are combined, rather than the nature of the constituents themselves, which gives rise to the acid or alkaline condition. Some metals combined with oxygen in one proportion, produce a body possessed of alkaline properties, in another proportion of acid properties. And on the other hand, ammonia and prussic acid prove that both the alkaline and acid conditions can exist independent of oxygen. These observations, by generalizing our notions of acids and alkalis, have rendered the definitions of them very imperfect. The difficulty of tracing a limit between the acids and alkalis is still increased, when we find a body sometimes performing the functions of an acid, sometimes of an alkali. Nor can we diminish this difficulty by having recourse to the beautiful law discovered by Sir H. Davy, that oxygen and acids go to the positive pole, and hydrogen, alkalis, and inflammable bases to the negative pole. We cannot in fact give the name of acid to all the bodies which go to the first of these poles, and that of alkali to those that go to the second; and if we wish to define the alkalis by bringing into view their electric energy, it would be necessary to compare them with the electric energy which is opposite to them. Thus we are always reduced to define alkalinity by the property which it has of saturating acidity, because alkalinity and acidity are two correlative and inseparable terms. M. Gay Lussac conceives the alkalinity which the metallic oxides enjoy, to be the result of two opposite properties, the alkalifying property of the metal, and the acidifying of oxygen, modified both by the combination and by the proportions.

The alkalis may be arranged into three classes: 1*st*, Those which consist of a metallic basis combined with oxygen. These are three in number, potash, soda, and lithia. 2*d*, That which contains no oxygen, viz. ammonia. 3*d*, Those containing oxygen, hydrogen, and carbon. In this class we have aconita, brucia, datura, delphia, hyosciama, morphia, strychnia, quinia, cinchonina, and perhaps some other *truly vegetable* alkalis. These are called by the German chemists, alkaloids. See VEGETABLE KINGDOM. The order of vegetable alkalis may be as numerous as that of vegetable acids. The earths, lime, barytes, and strontites, were enrolled among the alkalis by Fourcroy, but they have been kept apart by other systematic writers, and are called alkaline earths.

Besides neutralizing acidity, and thereby giving birth to salts, the first four alkalis have the following properties:—

1*st*, They change the purple colour of many vegetables to a green, the reds to a purple, and the yellows to a brown. If the purple have been reddened by acid, alkalis restore the purple.

2*d*, They possess this power on vegetable colours *after* being saturated with carbonic acid, by which criterion they are distinguishable from the alkaline earths.

3*d*, They have an acrid and urinous taste.

4*th*, They are powerful solvents or corrosives of animal matter; with which, as well as with fat oils in general, they combine, so as to produce neutrality.

5*th*, They are decomposed, or volatilized, at a strong red heat.

6*th*, They combine with water in every proportion, and also largely with alcohol.

7*th*, They continue to be soluble in water when neutralized with carbonic acid; while the alkaline earths thus become insoluble.

It is needless to detail at length Dr. Murray's speculations on alkalinity. They seem to flow from a partial view of chemical phenomena. According to him, either oxygen or hydrogen may generate alkalinity, but the combination of both principles is necessary to give this condition its utmost energy. "Thus the class of alkalis will exhibit the same relations as the class of acids. Some are compounds of a base with oxygen; such are the greater number of the metallic oxides, and probably of the earths. Ammonia is a compound of a base with hydrogen. Potash, soda, barytes, strontites, and probably lime, are compounds of bases with oxygen and hydrogen; and these last, like the analogous order among the acids, possess the highest power." Now, surely, perfectly dry and caustic barytes, lime, and strontites, as well as the dry potash and soda obtained by Gay Lussac and Thenard, are not inferior in alkaline power to the same bodies after they are slacked or combined with water. 100 parts of lime destitute of hydrogen, that is, pure oxide of calcium, neutralize 78 parts of carbonic acid. But 132 parts of Dr. Murray's *strongest* lime, that is the hydrate, are required to produce the same alkaline effect. If we ignite nitrate of barytes, we obtain, as is well known, a perfectly dry barytes, or protoxide of barium; but if we ignite crystallized barytes, we obtain the same alkaline earth combined with a prime equivalent of water. These two different states of barytes were demonstrated by M. Berthollet in an excellent paper published in the 2d volume of the Memoires D'Arcueil, so far back as 1809. "The first barytes" (that from crystallized barytes), says he, "presents all the characters of a combination; it is engaged with a substance which *diminishes* its action on other bodies, which renders it more fusible, and which gives it by fusion the appearance of glass. This substance is nothing else but water; but in fact, by adding a little water to the second barytes (that from ignited nitrate), and by urging it at the fire, we give it the properties of the first." Page 47. 100 parts of barytes void of hydrogen, or dry barytes, neutralize 28½ of dry carbonic acid. Whereas 111⅔ parts of the hydrate, or what Dr. Murray has styled the most energetic, are required to produce the same effect. In fact, it is not hydrogen which combines with the pure barytic earth, but hydrogen and oxygen in the state of water. The proof of this is, that when carbonic acid and that hydrate unite, the exact quantity of water is disengaged. The protoxide of barium, or pure barytes, has never been combined with hydrogen by any chemist.

ALKALI (MINERAL or FOSSIL). An old name of Soda.

ALKALI (PHLOGISTICATED, or PRUSSIAN). When a fixed alkali is ignited with bullock's blood, or other animal substances, and lixiviated, it is found to be in a great measure saturated with the prussic acid: from the theories formerly adopted respecting this combination, it was distinguished by the name of phlogisticated alkali. See Acid (Prussic).

ALKALI (VOLATILE). See Ammonia.

ALKALIMETER. The name first given by M. Descroizilles to an instrument or measure of his graduation, for determining the quantity of alkali in commercial potash and soda, by the quantity of dilute sulphuric acid of a known strength which a certain weight of them could neutralize.

ALKANET. The alkanet plant is a kind of bugloss, which is a native of the warmer parts of Europe, and cultivated in some of our gardens. The greatest quantities are raised in Germany and France, particularly about Montpelier, whence we are chiefly supplied with the roots. These are of a superior quality to such as are raised in England. This root imparts an elegant deep red colour to pure alcohol, to oils, to wax, and to all unctuous substances. The aqueous tincture is of a dull brownish colour; as is likewise the spirituous tincture when inspissated to the consistence of an extract. The principal use of alkanet root is, that of colouring oils, unguents, and lipsalves. Wax tinged with it, and applied on warm marble, stains it of a flesh colour, which sinks deep into the stone; as the spirituous tincture gives it a deep red stain.

As the colour of this root is confined to the bark, and the small roots have more bark in proportion to their bulk than the great ones, these also afford most colour.

ALLAGITE. A carbo-silicate of manganese.

ALLANITE. A mineral first recognized as a distinct species by Mr. Allen, of Edinburgh, to whose accurate knowledge and splendid collection, the science of mineralogy has been so much indebted in Scotland. Its analysis and description, by Dr. Thomson, were published in the 6th volume of the Edinburgh Phil. Trans. M. Giesecke found it in a granite rock in West Greenland. It is massive and of a brownish-black colour. External lustre, dull; internal, shining and resinous—fracture small conchoidal—opaque—greenish-grey streak—scratches glass and hornblende—brittle—spec. grav. 3.5 to 4.0. Froths and melts imperfectly before the blowpipe into a black scoria. It consists in 100 parts, of silica 35.4, oxide of cerium 33.9, oxide of iron 25.4, lime 9.2, alumina 4.1, and moisture 4.0. It has been also found crystallized in four, six, or eight-sided prisms. It closely resembles gadolinite, but may be distinguished from the thin fragments of the latter, being translucent on the edges, and of a fine green colour, whereas those of the former are commonly opaque and of a yellowish-brown. The ores of cerium analyzed by Berzelius, under the name of cerin, approach very closely in their composition to allanite.

ALLOCHROITE. A massive opaque mineral of a greyish, yellowish, or reddish colour. Quartz scratches it, but it strikes fire with steel. It has externally a glistening, and internally a glimmering lustre. Its fracture is uneven, and its fragments are translucent on the edges: sp. gr. 3.5 to 3.6.

It melts before the blowpipe into a black opaque enamel. Vauquelin's analysis is the following: Silica 35, lime 30.5, oxide of iron 17, alumina 8, carbonate of lime 6, oxide of manganese 3.5. M. Brogniart says it is absolutely infusible without addition, and that it requires a flux, as phosphate of soda or ammonia. With these it passes through a beautiful gradation of colours. It is covered at first with a species of enamel, which becomes on cooling reddish-yellow, then greenish, and lastly of a dirty yellowish-white. He represents it as pretty difficult to break. It was found by M. Dandrada in the iron mine of Virums, near Drammen in Norway. It is accompanied by carbonate of lime, protoxide of iron, and sometimes brown garnets.

ALLOPHANE. A mineral of a blue, and sometimes a green or brown colour, which occurs massive, or in imitative shapes. Lustre vitreous; fracture imperfectly conchoidal; transparent or translucent on the edges. Moderately hard, but very brittle. Sp. gr. 1.89. Composition, silica 21.92, alumina 32.2, lime 0.73, sulphate of lime 0.52, carbonate of copper 3.06, hydrate of iron 0.27, water 41.3. *Stromeyer*. It gelatinizes in acids. It is found in a bed of iron-shot limestone in greywacke slate, in the forest of Thuringia. It was called Riemannite.

ALLAY, or ALLOY. Where any precious metal is mixed with another of less value, the assayers call the latter the alloy, and do not in general consider it in any other point of view than as debasing or diminishing the value of the precious metal. Philosophical chemists have availed themelves of this term to distinguish all metallic compounds in general. Thus brass is called an alloy of copper and zinc; bell-metal an alloy of copper and tin.

Every alloy is distinguished by the metal which predominates in its composition, or which gives it its value. Thus English jewellery trinkets are ranked under alloys of gold, though most of them deserve to be placed under the head of copper. When mercury is one of the component metals, the alloy is called amalgam. Thus we have an amalgam of gold, silver, tin, &c. Since there are about 30 different permanent metals, independent of those evanescent ones that constitute the bases of the alkalis and earths, there ought to be about 870 different species of binary alloy. But only 132 species have been hitherto made and examined. Some metals have so little affinity for others, that as yet no compound of them has been effected, whatever pains have been taken. Most of these obstacles to alloying, arise from the difference in fusibility and volatility. Yet a few metals whose melting point is nearly the same, refuse to unite. It is obvious that two bodies will not combine, unless their affinity or reciprocal attraction be stronger than the cohesive attraction of their individual particles. To overcome this cohesion of the solid bodies, and render affinity predominant, they must be penetrated by caloric. If one be very difficult of fusion, and the other very volatile, they will not unite unless the reciprocal attraction be exceedingly strong. But if their degree of fusibility be almost the same, they are easily placed in the circumstances most favourable for making an alloy. If we are therefore far from knowing all the binary alloys which are possible, we are still further removed from knowing all the triple, quadruple, &c., which may exist. It must be confessed, moreover, that this department of chemistry has been imperfectly cultivated.

Besides, alloys are not, as far as we know, definitely regulated like oxides in the proportions of their component parts. 100 parts of mercury will combine with 4 or 8 parts of oxygen, to form two distinct oxides, the black and the red; but with no greater, less, or intermediate proportions. But 100 parts of mercury will unite with 1, 2, 3, or with any quantity up to 100 or 1000, of tin or lead. The alloys have the closest relations in their physical properties with the metals. They are all solid at the temperature of the atmosphere, except some amalgams: they possess metallic lustre, even when reduced to a coarse powder; are completely opaque, and more or less dense, according to the metals which compose them; are excellent conductors of electricity; crystallize more or less perfectly; some are brittle, others ductile and malleable; some have a peculiar odour; several are very sonorous and elastic. When an alloy consists of metals differently fusible, it is usually malleable while cold, but brittle while hot; as is exemplified in brass.

The density of an alloy is sometimes greater, sometimes less than the mean density of its components, showing that, at the instant of their union, a diminution or augmentation of volume takes place. The relation between the expansion of the separate metals and that of their alloys has been investigated only in a very few cases. Alloys containing a volatile metal are decomposed, in whole or in part, at a strong heat. This happens with those of arsenic, mercury, tellurium, and zinc. Those that consist of two differently fusible metals may often be decomposed by exposing them to a temperature capable of melting only one of them. This operation is called eliquation. It is practised on the great scale to extract silver from copper. The argentiferous copper is melted with 3½ times its weight of lead: and the triple alloy is exposed to a sufficient heat. The lead carries off the silver in its fusion, and leaves the copper under the form of a spongy lump. The silver is afterwards recovered from the lead by another operation.

Some alloys oxidize more readily by heat and air, than when the metals are separately treated. Thus 3 of lead, and 1 of tin, at a dull red, burn visibly, and are almost instantly oxidised. Each by itself, in the same circumstances, would oxidize slowly, and without the disengagement of light.

The formation of an alloy must be regulated by the nature of the particular metals, to which therefore we refer.

The degree of affinity between metals may be in some measure estimated by the greater or less facility with which, when of different degrees of fusibility or volatility, they unite, or with which they can after union be separated by heat. The greater or less tendency to separate into different proportional alloys, by long continued fusion, may also give some information on this subject. Mr. Hatchett remarked, in his admirable researches on metallic alloys, that gold made standard with the usual precautions by silver, copper, lead, antimony, &c. and then cast into vertical bars, was by no means an uniform compound; but that the top of the bar, corresponding to the metal at the bottom of the crucible, contained the larger proportion of gold. Hence, for thorough combination, two red-hot crucibles should be employed; and the liquefied metals should be alternately poured from the one into the other. And to prevent unnecessary oxidizement by exposure to air, the crucibles should contain, besides the metal, a mixture of common salt and pounded charcoal. The melted alloy should also be occasionally stirred up with a rod of pottery.

The most direct evidence of a chemical change having taken place in the two metals by combination, is when the alloy melts at a much lower temperature than the fusing points of its components. Iron, which is nearly infusible, when alloyed with gold acquires almost the fusibility of this metal. Tin and lead form solder, an alloy more fusible than either of its components; but the triple compound of tin, lead, and bismuth, is most remarkable on this account. The analogy is here strong, with the increase of solubility which salts acquire by mixture, as is exemplified in the uncrystallizable residue of saline solutions, or mother waters, as they are called. Sometimes two metals will not directly unite, which yet, by the intervention of a third, are made to combine. This happens with mercury and iron, as has been shown by Messrs. Aikin, who effected this difficult amalgamation by previously uniting the iron to tin or zinc.

The tenacity of alloys is generally, though not always, inferior to the mean of the separate metals. One part of lead will destroy the compactness and tenacity of a thousand of gold. Brass made with a small proportion of zinc, is more ductile than copper itself; but when one-third of zinc enters into its composition, it becomes brittle.

In common cases, the specific gravity affords a good criterion whereby to judge of the proportion in an alloy, consisting of two metals of different densities. But a very fallacious rule has been given in some respectable works, for comparing the specific gravity that should result from given quantities of two metals of known densities alloyed together, supposing no chemical penetration or expansion of volume to take place. Thus it has been taught, that if gold and copper be united in equal weights, the computed or mathematical specific gravity of the alloy is the arithmetical mean of the two specific gravities. This error was pointed out by me in a paper published in the 7th number of the Journal of Science and the Arts; and the correct rule was at the same time given. The details belong to the article Specific Gravity; but the rule merits a place here . The specific gravity of the alloy is found by dividing the sum of the weights by the sum of the volumes, compared to water, reckoned unity. Or in another form, the rule may be stated thus: Multiply the sum of the weights into the product of the two specific gravities for a numerator, and multiply each specific gravity into the weight of the other body, and add the two products together for a denominator. The quotient obtained by dividing the numerator by the denominator, is the true *computed* mean specific gravity; and that found by experiment, being compared with it, will show whether expansion or condensation of volume has attended the chemical combination. Gold having a specific gravity of 19.36, and copper of 8.87, being alloyed in equal weights, give on the fallacious rule of the aritmetical mean of the densities, $\frac{19.36+8.87}{2} = 14.11$; whereas the rightly calculated mean specific gravity is only 12.16. It is evident, that by comparing the former number with chemical experiment, we should be led to infer a prodigious condensation of volume beyond what really occurs.

A circumstance was observed by Mr. Hatchett to influence the density of metals, which *a priori* might be thought unimportant. When a bar of gold was cast in a vertical position, the density of the metal at the lower end of the bar was greater than that of the top, in the proportion of 17.364 to 17.035. Are we to infer that melted metal is a compressible fluid, or rather, that particles passing into the solid state under pressure, exert their cohesive attraction with adventitious strength? Under the title *metal*, a tabular view of metallic combinations will be found, and under that of the particular metal, the requisite information about its alloys.

ALLUVIAL FORMATIONS, in geology, are recent deposits in valleys or in plains, of the *detritus* of the neighbouring mountains. Gravel, loam, clay, sand, brown coal, wood coal, bog iron ore, and calc tuff, compose the alluvial deposits. The gravel and sand sometimes contain gold and tin, if the ores exist in the adjoining mountains. Petrified wood and animal skeletons are found in the alluvial clays and sand.

ALMANDINE. Precious garnet.

ALMONDS. Almonds consist chiefly of an oil of the nature of fat oils, together with farinaceous matter. The oil is so plentiful, and so loosely combined or mixed with the other principles, that it is obtained by simple pressure, and part of it may be squeezed out with the fingers. Five pounds and a half have yielded one pound six ounces of oil by cold expression, and three quarters of a pound more on heating them. There are two kinds of almonds, the sweet and bitter. The bitter almonds yield an oil as tasteless as that of the other, all the bitter matter remaining in the cake after the expression. Great part of the bitter matter dissolves by digestion, both in watery and spirituous liquors; and part arises with both in distillation. Rember obtained from them 1-3d of watery extract, and 3·32ds of spirituous. Bitter almonds are poisonous to birds, and to some animals. A water distilled from them, when made of a certain degree of strength, has been found from experiment to be poisonous to brutes; and there are instances of cordial spirits impregnated with them being poisonous to men. It seems, indeed, that the vegetable principle of bitterness in almonds and the kernels of other fruits, is destructive to animal life, when separated by distillation from the oil and farinaceous matter. The distilled water from laurel leaves appears to be of this nature, and its poisonous effects are well known. See ACID (PRUSSIC).

Sweet almonds are made into an emulsion by trituration with water, which on standing separates a thick cream floating on the top. The emulsion may be curdled by heat, or the addition of alcohol or acids. The whey contains gum, extractive matter, and sugar, according to Professor Proust; and the curd, when washed and dried, yields oil by expression, and afterward by distillation the same products as cheese. The whey is a good diluent.

Prussic or hydrocyanic acid is the deleterious ingredient in bitter almonds. The best remedy, after emetics, is a combination of sulphate of iron with bicarbonate of potash.

ALOES. This is a bitter juice, extracted from the leaves of a plant of the same name. Three sorts of aloes are distinguished in the shops by the names of aloe soccotrina, aloe hepatica, and aloe caballina. The first denomination, which is applied to the purest kind, is taken from the island of Zocotora; the second, or next in quality, is called hepatica, from its liver colour; and the third, caballina, from the use of this species being confined to horses. These kinds of aloes are said to differ only in purity, though, from the difference of their flavours, it is probable that they may be obtained in some instances from different species of the same plant. It is certain, however, that the different kinds are all prepared at Morviedro in Spain, from the same leaves of the common aloe. Deep incisions are made in the leaves, from which the juice is suffered to flow; and this, after decantation from its sediment, and inspissation in the sun, is exposed to sale in leathern bags by the name of soccotrine aloes. An additional quantity of juice is obtained by pressure from the leaves; and this, when decanted from its sediment and dried, is the hepatic aloes. And lastly, a portion of juice is obtained by strong pressure of the leaves, and is mixed with the dregs of the two preceding kinds to form the caballine aloes. The first kind is said to contain much less resin. The principal characters of good aloes are these: it must be glossy, not very black, but brown; when rubbed or cut, of a yellow colour; compact, but easy to break; easily soluble; of an unpleasant peculiar smell, which cannot be described, and an extremely bitter taste.

Aloes appears to be an intimate combination of gummy resinous matter, so well blended together, that watery or spirituous solvents, separately applied, dissolve the greater part of both. It is not determined whether there be any difference in the medical properties of these solutions. Both are purgative, as is likewise the aloes in substance; and, if used too freely, are apt to prove heating, and produce hemorrhoidal complaints.

Braconnot imagines he has detected in aloes a peculiar principle, similar to the *bitter resinous*, which Vauquelin has found in many febrifuge barks. The recent juice of the leaves absorbs oxygen, and becomes a fine reddish-purple pigment.

ALUDEL. The process of sublimation differs from distillation in the nature of its product, which, instead of becoming condensed in a fluid, assumes the solid state, and the form of the receivers may of course be very different. The receivers for sublimates are of the nature of chimnies, in which the elastic products are condensed, and adhere to their internal surface. It is evident that the head of an alembic will serve very well to receive and condense such sublimates as are not very volatile. The earlier chemists, whose notions of simplicity were not always the most perfect, thought proper to use a number of similar heads, one above the other, communicating in succession by means of a perforation in the superior part of each, which received the neck of the capital immediately above it. These heads differing in no respect from the usual heads of alembics, excepting in their having no nose or beak, and in the other circumstances here mentioned, were called aludels. They are seldom now to be seen in chemical laboratories, because the operations of this art may be performed with greater simplicity of instruments, provided attention be paid to the heat and other circumstances.

ALUM. See Alumina, Sulphate of.

ALUM-EARTH. A massive mineral, of a blackish-brown colour, a dull lustre, an earthy and somewhat slaty fracture, sectile, and rather soft. By Klaproth's analysis it contains, charcoal 19.65, silica 40, alumina 16, oxide of iron 6.4, sulphur 2.84, sulphates of lime and potash each 1.5, sulphate of iron 1.8, magnesia and muriate of potash 0.5, and water 10.75.

ALUM-SLATE. 1. Common. This mineral occurs both massive and in insulated balls of a greyish-black colour, dull lustre, straight slaty fracture, tabular fragments, streak coloured like itself. Though soft, it is not very brittle. Effloresces, acquiring the taste of alum.

2. Glossy Alum-slate. A massive mineral of a bluish-black colour. The rents display a variety of lively purple tints. It has a semimetallic lustre in the fracture, which is straight, slaty, or undulating. There is a soft variety of it, approaching in appearance to slate clay. By exposure to air its thickness is prodigiously augmented by the formation of a saline efflorescence, which separates its thinnest plates. These afterwards exfoliate in brittle sections, causing entire disintegration.

ALUMINA. One of the primitive earths, which, as constituting the plastic principle of all clays, loams, and boles, was called argil or the argillaceous earth, but now, as being obtained in greatest purity from alum, is styled alumina. It was deemed elementary matter till Sir H. Davy's celebrated electro-chemical researches led to the belief of its being, like barytes and lime, a metallic oxide.

The purest native alumina is found in the oriental gems, the sapphire and ruby. They consist of nothing but this earth, and a small portion of colouring matter. The native porcelain clays or kaolins, however white and soft, can never be regarded as pure alumina. They usually contain fully half their weight of silica, and frequently other earths. To obtain pure alumina we dissolve alum in 20 times its weight of water, and add to it a little of the solution of carbonate of soda, to throw down any iron which may be present. We then drop the supernatant liquid into a quantity of the water of ammonia, taking care not to add so much of the aluminous solution as will saturate the ammonia. The volatile alkali unites with the sulphuric acid of the alum, and the earthy basis of the latter is separated in a white spongy precipitate. This must be thrown on a filter, washed, or edulcorated, as the old chemists expressed it, by repeated affusions of water, and then dried. Or if an alum, made with ammonia instead of potash, as is the case with some French alums, can be got, simple ignition dissipates its acid and alkaline constituents, leaving pure alumina.

Alumina prepared by the first process is white, pulverulent, soft to the touch, adheres to the tongue, forms a smooth paste without grittiness in the mouth, insipid, inodorous, produces no change in vegetable colours, insoluble in water, but mixes with it readily in every proportion, and retains a small quantity with considerable force; is infusible in the strongest heat of a furnace, experiencing merely a condensation of volume and consequent hardness, but is in small quantities melted by the oxyhydrogen blowpipe. Its specific gravity is 2.000, in the state of powder, but by ignition it is augmented.

Every analogy leads to the belief that alumina contains a peculiar metal, which may be called aluminum. The first evidences obtained of this position are presented in Sir H. Davy's researches. Iron negatively electrified by a very high power being fused in contact with pure alumina, formed a globule whiter than pure iron, which effervesced slowly in water, becoming covered with a white powder. The solution of this in muriatic acid, decomposed by an alkali, afforded alumina and oxide of iron. By passing potassium in vapour through alumina heated to whiteness, the greatest part of the potassium became converted into potash, which formed a coherent mass with that part of the alumina not decompounded; and in this mass there were numerous grey particles, having the metallic lustre, and which became white when heated in the air, and which slowly effervesced in water. In a similar experiment made by the same illustrious chemist, a strong red heat only being applied to the alumina, a mass was obtained, which took fire spontaneously by exposure to air, and which effervesced violently in water. This mass was probably an alloy of aluminum and potassium. The conversion of potassium into its oxide, dry potash, by alumina, proves the presence of oxygen in the latter. When regarded as an oxide, Sir H. Davy estimates its oxygen and basis to be to one another as 15 to 33; or as 10 to 22. The prime equivalent of alumina would thus appear to be $1.0 + 2.2 = 3.2$.

But Berzelius's analysis of sulphate of alumina seems to indicate 2.136 as the quantity of the earth which combines with 5 of the acid. Hence aluminum will come to be represented by $2.136 - 1 = 1.136$. We shall presently show that his analysis, both of alum and sulphate of alumina, may be reconciled nearly to Sir H. Davy's equivalent prime $= 3.2$. That of aluminum will become of course 2.2.

Alumina which has lost its plasticity by ignition, recovers it by being dissolved in an acid or alkaline menstruum, and then precipitated. In this state it is called a hydrate, for when dried in a steam heat it retains much water; and therefore resembles in composition wavellite, a beautiful mineral, consisting almost entirely of alumina, with about 28 per cent. of water. Alumina is widely diffused in nature. It is a constituent of every soil, and of almost every rock. It is the basis of porcelain, pottery, bricks, and crucibles. Its affinity for vegetable colouring matter is made use of in the preparation of lakes, and in the arts of dyeing and calico printing. Native combinations of alumina constitute the fuller's earth, ochres, boles, pipe-clays, &c.

ALUMINA (SALTS of).

These salts have the following general characters:

1. Most of them are very soluble in water, and their solutions have a sweetish acerb taste.

2. Ammonia throws down their earthy base, even though they have been previously acidulated with muriatic acid.

3. At a strong red heat they give out a portion of their acid.

4. *Phosphate* of ammonia gives a white precipitate.

5. *Hydriodate* of potash produces a flocculent precipitate of a white colour, passing into a permanent yellow.

6. They are not affected by oxalate of ammonia, tartaric acid, ferroprussiate of potash, or tincture of galls; by the first two tests they are distinguishable from yttria, and by the last two from that earth and glucina.

7. If bisulphate of potash be added to a solution of an aluminous salt, moderately concentrated, octahedral crystals of alum will form.

Acetate of Alumina. By digesting *strong* acetic acid on newly precipitated alumina, this saline combination can be directly formed. Vinegar of ordinary strength scarcely acts on the earth. But the salt is seldom made in this way. It is prepared in large quantities for the calico printers, by decomposing alum with acetate of lead; or more economically with aqueous acetate of lime, having a specific gravity of about 1.050; a gallon of which, equivalent to nearly half a pound avoirdupoise of dry acetic acid, is employed for every 2¼lb. of alum. A sulphate of lime is formed by complex affinity, which precipitates, and an acetate of alumina floats above. The above proportion of alum is much beyond the equivalent quantity; and the specific gravity of the liquid is consequently raised by the excess of salt. It is usually 1.080. By careful evaporation capillary crystals are formed, which readily deliquesce. M. Gay Lussac made some curious observations on the solutions of this salt. Even when made with cold saturated solutions of alum and acetate of lead, and consequently but little concentrated, it becomes turbid when heated to 122° Fahr.; and at a boiling heat a precipitate falls of about one-half of the whole salt. On cooling it is redissolved. This decomposition by heat, which would be prejudicial to the calico printer, is prevented by the excess of alum which is properly used in actual practice. M. Gay Lussac thinks this phenomenon has considerable analogy with the coagulation of albumen by heat; the particles of the water, and of the solid matter, being carried by the heat out of their sphere of activity, separate. It is probably a subacetate which falls down, as well as that which is obtained by drying the crystals. Wenzel's analysis of acetate of alumina gives 73.81 acid to 26.19 base in 100 parts. If we suppose it to consist, like the sulphate, of three primes of acid to two of alumina, we shall have for its equivalent proportions, 20 of dry acid + 6.4 earth or 75.8 + 24.2 = 100. As alum contains, in round numbers, about 1-9th of earthy base, 8 oz. of real acetic acid present in the gallon of the redistilled pyrolignous, would require about 2¼ lbs. of alum for exact decomposition. The excess employed is found to be useful.

The affinity between the constituents of this salt is very feeble. Hence the attraction of cotton fibre for alumina, aided by a moderate heat, is sufficient to decompose it.

The following salts of alumina are insoluble in water:—Arseniate, borate, phosphate, tungstate, mellate, saclactate, lithate, malate, camphorate. The oxalate is uncrystallizable. It consists of 56 acid and water, and 44 alumina. The tartrate does not crystallize. But the tartrate of potash and alumina is remarkable, according to Thenard, for yielding no precipitate, either by alkalis or alkaline carbonates. The supergallate crystallizes. There seems to be no dry carbonate. A supernitrate exists very difficult to crystallize. Its specific gravity is 1.645. A moderate heat drives off the acid. The muriate is easily made by digesting muriatic acid on gelatinous alumina. It is colourless, astringent, deliquescent, uncrystallizable, reddens turnsole, and forms a gelatinous mass by evaporation. Alcohol dissolves at 60° half its weight of this salt. A dull red heat separates the acid from the alumina. Its composition is, according to Bucholz, 29.8 acid, 30.0 base, 40.2 water, in 100 parts.

Sulphate of alumina exists under several modifications. The simple sulphate is easily made, by digesting sulphuric acid on pure clay. The salt thus formed crystallizes in thin soft plates, having a pearly lustre. It has an astringent taste, and is so soluble in water as to crystallize with difficulty. When moderately heated the water escapes, and, at a higher temperature, the acid. Berzelius has chosen this salt for the purpose of determining the equivalent of alumina. He considers the dry sulphate as a compound of 100 parts of sulphuric acid with 42.722 earth. This makes the equivalent 21.361, oxygen being reckoned 10, if we consider it a compound of a prime proportion of each. But if we regard it as consisting of 3 of acid and 2 of base, we shall have 32.0 for the prime equivalent of alumina. The reason for assigning this number will appear in treating of the next salt.

ALUM. This important salt has been the object of innumerable researches both with regard to its fabrication and composition. It is produced, but in a very small quantity, in the native state; and this is mixed with heterogeneous matters. It effloresces in various forms upon ores during calcination, but it seldom occurs crystallized. The greater part of this salt is factitious, being extracted from various minerals called alum ores, such as, 1. Sulphurated clay. This constitutes the purest of all aluminous ores, namely, that of la Tolfa, near Civita Vecchia, in Italy. It is white, compact, and as hard as indurated clay, whence it is called *petra aluminaris.* It is tasteless and mealy; one hundred parts of this ore contain above forty of sulphur and fifty of clay, a small quantity of potash, and a little iron. Bergman says it contains forty-three of sulphur in one hundred, thirty-five of clay, and twenty-two of siliceous earth. This ore is first torrefied to acidify the sulphur, which then acts on the clay, and forms the alum.

2. The pyritaceous clay, which is found at Schwemsal, in Saxony, at the depth of ten or twelve feet. It is a black and hard, but brittle substance, consisting of clay, pyrites, and bitumen. It is exposed to the air for two years; by which means the pyrites is decomposed, and the alum is formed. The alum ores of Hesse and Liege are of this kind; but they are first torrefied, which is said to be a disadvantageous method.

3. The schistus aluminaris contains a variable proportion of petroleum and pyrites intimately mixed with it. When the last are in a very large quantity, this ore is rejected as containing too much iron. Professor Bergman very properly suggested, that by adding a proportion of clay, this ore may turn out advantageously for producing alum. But if the petrol be considerable, it must be torrefied. The mines of Becket in Normandy, and those of Whitby in Yorkshire, are of this species.

4. Volcanic aluminous ore. Such is that of Solfaterra, near Naples. It is in the form of a white saline earth, after it has effloresced in the air; or else it is in a stony form.

5. Bituminous alum ore is called shale, and is in the form of a schistus, impregnated with so much oily matter, or bitumen, as to be inflammable. It is found in Sweden, and also in the coal mines at Whitehaven, and elsewhere.

Chaptal has fabricated alum on a large scale from its component parts. For this purpose he constructed a chamber 91 feet long, 48 wide, and 31 high in the middle. The walls are of common masonry, lined with a pretty thick coating of plaster. The floor is paved with bricks, bedded in a mixture of raw and burnt clay; and this pavement is covered with another, the joints of which overlap those of the first, and instead of mortar the bricks are joined with a cement of equal parts of pitch, turpentine, and wax, which, after having been boiled till it ceases to swell, is used hot. The roof is of wood, but the beams are very close together, and grooved lengthwise, the intermediate space being filled up by planks fitted into the grooves, so that the whole is put together without a nail. Lastly, the whole of the inside is covered with three or four successive coatings of the cement above-mentioned, the first being laid on as hot as possible; and the outside of the wooden roof was varnished in the same manner. The purest and whitest clay being made into a paste with water, and formed into balls half a foot in diameter, these are calcined in a furnace, broken to pieces, and a stratum of the fragments laid on the floor. A due proportion of sulphur is then ignited in the chamber, in the same manner as for the fabrication of sulphuric acid; and the fragments of burnt clay, imbibing this as it forms, begin after a few days to crack and open, and exhibit an efflorescence of sulphate of alumina. When the earth has completely effloresced, it is taken out of the chamber, exposed for some time in an open shed, that it may be the more intimately penetrated by the acid, and is then lixiviated and crystallized in the usual manner. The cement answers the purpose of lead on this occasion very effectually, and, according to M. Chaptal, costs no more than lead would at three farthings a pound.

Curaudau has lately recommended a process for making alum without evaporation. One hundred parts of clay and five of muriate of soda are kneaded into a paste with water, and formed into loaves. With these a reverberatory furnace is filled, and a brisk fire is kept up for two hours. Being powdered, and put into a sound cask, one-fourth of their weight of sulphuric acid is poured over them by degrees, stirring the mixture well at each addition. As soon as the muriatic gas is dissipated, a quantity of water equal to the acid is added, and the mixture stirred as before. When the heat is abated, a little more water is poured in; and this is repeated till eight or ten times as much water as there was acid is added. When the whole has settled, the clear liquor is drawn off into leaden vessels, and a quantity of water equal to this liquor is poured on the sediment. The two liquors being mixed, a solution of potash is added to them, the alkali in which is equal to one-fourth of the weight of the sulphuric acid. Sulphate of potash may be used; but twice as much of this as of the alkali is necessary. After a certain time the liquor by cooling affords crystals of alum equal to three times the weight of the acid used. It is refined by dissolving it in the smallest possible quantity of boiling water. The residue may be washed with more water, to be employed in lixiviating a fresh portion of the ingredients.

As the mother water still contains alum, with sulphate of iron very much oxided, it is well adapted to the fabrication of prussian blue. This mode of making alum is particularly advantageous to the manufacturers of prussian blue, as they may calcine their clay at the same time with their animal matters without additional expense: they will have no need in this case to add potash; and the presence of iron, instead of being injurious, will be very useful. If they wished to make alum for sale, they might use the solution of sulphate of potash arising from the washing of their prussian blue, instead of water, to dissolve the combination of alumina and sulphuric acid.

The residuums of distillers of aquafortis are applicable to the same purposes, as they contain the alumina and potash requisite, and only require to be reduced to powder, sprinkled with sulphuric acid, and lixiviated with water, in the manner directed above. The mother waters of these alums are also useful in the fabrication of prussian blue. As the residuum of aquafortis contains an over-proportion of acid, it will be found of advantage to add an eighth of its weight of clay calcined as above.

The most extensive alum manufactory in Great Britain is at Hurlett, near Paisley, on the estate of the Earl of Glasgow. The next in magnitude is at Whitby: of whose state and processes an instructive account was published by Mr. Winter in the 25th volume of Nicholson's Journal. The stratum of aluminous schistus is about 29 miles in width, and it is covered by strata of alluvial soil, sandstone, ironstone, shell, and clay. The alum schist is generally found disposed in horizontal laminæ. The upper part of the rock is the most abundant in sulphur; so that a cubic yard taken from the top of the stratum is 5 times more valuable than the same bulk 100 feet below.

If a quantity of the schistus be laid in a heap, and moistened with sea-water, it will take fire spontaneously, and will continue to burn till the whole inflammable matter be consumed. Its colour is bluish-grey. Its sp. gravity is 2.48. It imparts a bituminous principle to alcohol. Fused with an alkali, muriatic acid precipitates a large proportion of silex.

The expense of digging and removing to a distance of 200 yards one cubic yard of the schistose rock, is about sixpence-halfpenny. A man can earn from 2*s.* 6*d.* to 3*s.* a-day. The rock, broken into small pieces, is laid on a horizontal bed of fuel, composed of brushwood, &c. When about 4 feet in height of the rock is piled on, fire is set to the bottom, and fresh rock continually poured upon the pile. This is continued until the calcined heap be raised to the height of 90 or 100 feet. Its horizontal area has also been progressively extended at the same time, till it forms a great bed nearly 200 feet square, having about 100,000 yards of solid measurement. The rapidity of the combustion is allayed by plastering up the crevices with small schist moistened. Notwithstanding of this precaution, a great deal of sulphuric or sulphurous acid is dissipated. 130 tons of calcined schist produce on an average 1 ton of alum. This result has been deduced from an average of 150,000 tons.

The calcined mineral is digested in water contained in pits that usually contain about 60 cubic yards. The liquid is drawn off into cisterns, and afterwards pumped up again upon fresh calcined *mine.* This is repeated until the specific gravity becomes 1.15. The half-exhausted schist is then covered with water to take up the whole soluble matter. The strong liquor is drawn off into settling cisterns, where the sulphate of lime, iron, and earth are deposited. At some works the liquid is boiled, which aids its purification. It is then run into leaden pans 10 feet long, 4 feet 9 inches wide, 2 feet 2 inches deep at the one end, and 2 feet 8 inches at the other. This slope makes them be easily emptied. Here the liquor is concentrated at a boiling heat. Every morning the pans are emptied into a settling cistern, and a solution of muriate of potash, either pretty pure from the manufacturer, or crude and compound from the soap-boiler, is added. The quantity of muriate necessary is determined by a previous experiment in a basin, and is regulated for the workmen by the hydrometer. By this addition the pan liquor, which had acquired a specific gravity of 1.4 or 1.5, is reduced to 1.35. After being allowed to settle for two hours, it is run off into the coolers to be crystallized. At a greater sp. gravity than 1.35, the liquor, instead of crystallizing, would, when it cools, present us with a solid magma, resembling grease. Urine is occasionally added, to bring it down to the proper density.

After standing 4 days the mother waters are drained off, to be pumped into the pans on the succeeding day. The crystals of alum are washed in a tub, and drained. They are then put into a lead pan, with as much water as will make a saturated solution at the boiling point. Whenever this is effected, the solution is run off into casks. At the end of 10 or 16 days, the casks are unhooped and taken asunder. The alum is found exteriorly in a solid cake, but in the interior cavity, in large pyramidal crystals, consisting of octahëdrons, inserted successively into one another. This last process is called roching. Mr. Winter says, that 22 tons of muriate of potash will produce 100 tons of alum, to which 31 tons of the black ashes of the soap-boiler, or 73 of kelp, are equivalent. Where much iron exists in the alum ore, the alkaline muriate, by its decomposition, gives birth to an uncrystallizable muriate of iron. The alum manufactured in the preceding mode is a sulphate of alumina and potash. There is another alum which exactly resembles it. This is a sulphate of alumina and ammonia. Both crystallize in regular octaëdrons, formed by two four-sided pyramids joined base to base. Alum has an astringent sweetish taste. Its sp. gravity is about 1.71. It reddens the vegetable blues. It is soluble in 16 parts of water at 60°, and in ¾ths of its weight at 212°. It effloresces superficially on exposure to air, but the interior remains long unchanged. Its water of crystallization is sufficient at a gentle heat to fuse it. If the heat be increased it froths up, and loses fully 45 per cent. of its weight in water. The spongy residue is called burnt or calcined alum, and is used by surgeons as a mild escharotic, A violent heat separates a great portion of its acid.

Alum was thus analyzed by Berzelius: 1st, 20 parts (grammes) of pure alum lost by the heat of a spirit lamp 9 parts, which gives 45 per cent. of water. The dry salt was dissolved in water, and its acid precipitated by muriate of barytes; the sulphate of which, obtained after ignition, weighed 20 parts; indicating in 100 parts 34.3 of dry sulphuric acid. 2d, Ten parts of alum were dissolved in water, and digested with an excess of ammonia. Alumina, well washed and burnt, equivalent to 10.67 per cent. was obtained. In another experiment, 10.86 per cent. resulted. 3d, Ten parts of alum dissolved in water, were digested with carbonate of strontites, till the earth was completely separated. The sulphate of potash, after ignition, weighed 1.815, corresponding to 0.981 potash, or in 100 parts to 9.81.

Alum, therefore, consists of

Sulphuric acid	34.33
Alumina	10.86
Potash	9.81
Water	45.00
	100.00
or, Sulphate of alumina	36.85
Sulphate of potash	18.15
Water	45.00
	100.00

Thenard's analysis, Ann. de Chimie, vol. 59. or Nicholson's Journal, vol. 18. coincides perfectly with that of Berzelius in the product of sulphate of barytes. From 400 parts of alum, he obtained 490 of the ignited barytic salt; but the alumina was in greater proportion, equal to 12.54 per cent. and the sulphate of potash less, or 15.7 in 100 parts.

Vauquelin, in his last analysis, found 48.58 water; and by Thenard's statement there are indicated 34.23 dry acid,

7.14 potash,
12.54 alumina,
46.09 water,

100.00

If we rectify Vauquelin's erroneous estimate of the sulphate of barytes, his analysis will also coincide with the above. Alum, therefore, differs from the simple sulphate of alumina previously described, which consisted of 3 prime equivalents of acid and 2 of earth, merely by its assumption of a prime of sulphate of potash. It is probable that all the aluminous salts have a similar constitution. It is to be observed, however, that the number 34.36 resulting from the theoretic proportions, is, according to Gilbert's remarks on the essay of Berzelius, the just representation of the dry acid in 100 of sulphate of barytes, by another analysis, which makes the prime of barytes 9.57.

Should ammonia be suspected in alum, it may be detected, and its quantity estimated by mixing quick lime with the saline solution, and exposing the mixture to heat in a retort, connected with a Woolfe's apparatus. The water of ammonia being afterwards saturated with an acid, and evaporated to a dry salt, will indicate the quantity of pure ammonia in the alum. A variety of alum, containing both potash and ammonia, may also be found. This will occur where urine has been used, as well as muriate of potash, in its fabrication. If any of these sulphates of alumina and potash be acted on in a watery solution, by a gelatinous alumina, a neutral triple salt is formed, which precipitates in a nearly insoluble state.

When alum in powder is mixed with flour or sugar, and calcined, it forms the pyrophorus of Homberg.

Mr. Winter first mentioned, that another variety of alum can be made with *soda*, instead of potash. This salt, which crystallizes in octahedrons, has been also made with pure muriate of soda, and bisulphate of alumina, at the laboratory of Hurlett, by Mr. W. Wilson. It is extremely difficult to form, and effloresces like the sulphate of soda.

On the subject of soda-alum, I published a short paper in the Journal of Science for July 1822. The form and taste of this salt are exactly the same as those of common alum; but it is less hard, being easily crushed between the fingers, to which it imparts an appearance of moisture. Its specific gravity is 1.6. 100 parts of water at 60° F. dissolve 110 of it; forming a solution, whose sp. gravity is 1.296. In this respect, potash-alum is very different.

For 100 parts of water dissolve only from 8 to 9 parts, forming a saturated solution, whose sp. gr. is no more than 1.0466. Its constituents are by my analysis,—

Sulphuric acid,	34.00	4 primes,		33.96
Alumina,	10.75	3	—	10.82
Soda,	6.48	1	—	6.79
Water,	49.00	25	—	48.43
	100.23			100.00

Or it consists of 3 primes sulphate of alumina + 1 sulphate of soda. To each of the former, 5 primes of water may be assigned, and to the latter 10, as in Glauber's salt.

The only injurious contamination of alum is sulphate of iron. It is detected by ferroprussiate of potash. To get rid of it cheaply, M. Thenard recommended dissolving the alum in boiling water, and agitating the solution with rods as it cools. The salt is thus reduced to a fine granular powder, which being washed two or three times with cold water, and drained, yields a perfectly pure alum. For a very advantageous mode of concentrating alum liquors, as well as those of other salts, on the great scale, see EVAPORATION.

Mr. Phillips describes in the 4th volume of the Annals of Philosophy, N. S. a new sulphate of alumina, which he obtained by putting moist alumina into dilute sulphuric acid, and adding more occasionally, until it remained in excess; being now filtered, a clear dense solution was obtained, which, when dropped into water, instantly let fall a precipitate, almost as abundant as that from muriate of antimony. It also began to precipitate immediately, even of itself, though no tendency of this kind was observed, as long as the excess of alumina remained mixed with it. The deposition went on for several months; but the clear part was always precipitable by water. Another property of this sulphate of alumina, is that if heated to 160° or 170° Fahr. it becomes opaque and thick; but upon cooling, in a few days it becomes clear again. Mr. Phillips considers the number 27 as representing the atom of alumina to hydrogen $= 1$; and the above salt as consisting of 2 atoms sulphuric acid $= 40 \times 2 = 80 + 3$ atoms alumina $= 27 \times 3 = 81$; or on the oxygen scale of $2 \times 5 = 10$ acid $+ 3.375 \times 3 = 10.125$ alumina.

Alum is used in large quantities in many manufactories. When added to tallow, it renders it harder. Printers' cushions, and the blocks used in the calico manufactory, are rubbed with burned alum to remove any greasiness, which might prevent the ink or colour from sticking. Wood sufficiently soaked in a solution of alum does not easily take fire; and the same is true of paper impregnated with it, which is fitter to keep gunpowder, as it also excludes moisture. Paper impregnated with alum is useful in whitening silver, and silvering brass without heat. Alum mixed in milk helps the separation of its butter. If added in a very small quantity to turbid water, in a few minutes it renders it perfectly limpid, without any bad taste or quality; while the sulphuric acid imparts to it a very sensible acidity, and does not precipitate so soon, or so well, the opaque earthy mixtures that render it turbid, as I have often tried. It is used in making pyrophorus, in tanning, and many other manufactories, particularly in the art of dyeing, in which it is of the greatest and most important use, by cleansing and opening the pores on the surface of the substance to be dyed, rendering it fit for receiving the colouring particles, (by which the alum is generally decomposed), and at the same time making the colour fixed. Crayons generally consist of the earth of alum, finely powdered, and tinged for the purpose. In medicine it is employed as an astringent.

ALUMINITE. A mineral of a snow-white colour, dull, opaque, and having a fine earthy fracture. It has a glistening streak. It is found in kidney-shaped pieces, which are soft to the touch, and adhere slightly to the tongue. Sp. gravity, 1.67.

It consists of sulphuric acid,	19.25
Alumina,	32.50
Water,	47.00
Silica, lime, and oxide of iron,	1.25
	100.00

The above alum ore is found chiefly in the alluvial strata round Halle in Saxony.

AMADOU. It is a variety of the *boletus igniarius*, found on old ash and other trees. It is boiled in water to extract its soluble parts, then dried and beat with a mallet to loosen its texture. It has now the appearance of very spongy doe-skin leather. It is lastly impregnated with a solution of nitre, and dried, when it is called spunk, or German tinder; a substance much used on the continent for lighting fires, either from the collision of flint and steel, or from the sudden condensation of air in the atmospheric pyrophorus.

AMALGAM. This name is applied to the combinations of mercury with other metallic substances. See MERCURY.

AMBER is a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semitransparent or opaque, and of a glossy surface: it is found of all colours, but chiefly yellow or orange, and often contains leaves or insects; its specific gravity is from 1.065 to 1.100; its fracture is even, smooth, and glossy; it is capable of a fine polish, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable smell, particularly when it melts, that is at 550° of Fahrenheit, but it then loses its transparency; projected on burning coals, it burns with a whitish flame, and a whitish-yellow smoke, but gives very little soot, and leaves browhish ashes; it is insoluble in water and alcohol, though the latter, when highly rectified, extracts a reddish colour from it; but it is soluble in the sulphuric acid, which then acquires a reddish-purple colour, and is precipitable from it by water. No other acid dissolves it, nor is it soluble in essential or expressed oils, without some decomposition and long digestion; but pure alkali dissolves it. By distillation it affords a small quantity of water, with a little acetic acid, an oil, and a peculiar acid. See ACID (SUCCINIC). The oil rises at first colourless; but, as the heat increases, becomes brown, thick, and empyreumatic. The oil may be rectified by successive distillations, or it may be obtained very light and limpid at once, if it be put into a glass alembic with water, as the elder Rouelle directs, and distilled at a heat not greater than 212° Fahr. It requires to be kept in stone bottles, however, to retain this state; for in glass vessels it becomes brown by the action of light.

Amber is met with plentifully in regular mines in some parts of Prussia. The upper surface is composed of sand, under which is a stratum of loam, and under this a bed of wood, partly entire, but chiefly mouldered or changed into a bituminous substance. Under the wood is a stratum of sulphuric or rather aluminous mineral, in which the amber is found. Strong sulphurous exhalations are often perceived in the pits.

Detached pieces are also found occasionally on the sea-coast in various countries. It has been found in gravel beds near London. In the Royal Cabinet at Berlin there is a mass of 18 lbs. weight, supposed to be the largest ever found. Jussieu asserts, that the delicate insects in amber, which prove the tranquillity of its formation, are not European. M. Hauy has pointed out the following distinctions between mellite and copal, the bodies which most closely resemble amber. Mellite is infusible by heat. A bit of copal heated at the end of a knife takes fire, melting into drops, which flatten as they fall; whereas amber burns with spitting and frothing; and when its liquefied particles drop, they rebound from the plane which receives them. The origin of amber is at present involved in perfect obscurity, though the rapid progress of vegetable chemistry promises soon to throw light on it. Various frauds are practised with this substance. Neumann states as the common practices of workmen the two following: The one consists in surrounding the amber with sand in an iron pot, and cementing it with a gradual fire for forty hours, some small pieces placed near the sides of the vessel being occasionally taken out for judging of the effect of the operation: the second method, which he says is that most generally practised, is by digesting and boiling the amber about twenty hours with rapeseed oil, by which it is rendered both clear and hard.

Werner has divided it into two sub-species, the white and the yellow; but there is little advantage in the distinction. Its ultimate constituents are carbon, hydrogen, and oxygen. Although my experiments on the ultimate analysis of amber were conducted carefully with re-trituration and re-ignition, no good atomic configuration of it occurred to me. It yielded in 100 parts, 70.68 carbon, 11.62 hydrogen, and 17.77 oxygen; or of the elements of water 20 + hydrogen in excess 9.4, independently of the carbon. *Phil. Trans.* 1822.

In the second volume of the Edinburgh Philosophical Journal, Dr. Brewster has given an account of some optical properties of amber, from which he considers it established beyond a doubt that amber is an *indurated vegetable juice;* and that the traces of a regular structure, indicated by its action upon polarized light, are not the effect of the ordinary laws of crystallization by which *mellite* has been formed, but are produced by the same causes which influence the mechanical condition of gum arabic, and other gums, which are known to be formed by the successive deposition and induration of vegetable fluids.

Amber is also used in varnishes. See VARNISH and OIL of AMBER.

AMBERGRIS is found in the sea, near the coasts of various tropical countries; and has also been taken out of the intestines of the physeter macrocephalus, the spermaceti whale. As it has not been found in any whales but such as are dead or sick, its production is generally supposed to be owing to disease, though some have a little too peremptorily affirmed it to be the cause of the morbid affection. As no large piece has ever been found without a greater or less quantity of the beaks of the sepia octopodia, the common food of the spermaceti whale, interspersed throughout its substance, there can be little doubt of its originating in the intestines of the whale; for if it were occasionally swallowed by it only, and then caused disease, it must much more frequently be found without these, when it is met with floating in the sea, or thrown upon the shore.

Ambergris is found of various sizes, generally in small fragments, but sometimes so large as to weigh near two hundred pounds. When taken from the whale it is not so hard as it becomes afterward on exposure to the air. Its specific gravity ranges from 780 to 926. If good, it adheres like wax to the edge of a knife with which it is scraped, retains the impression of the teeth or nails, and emits a fat odoriferous liquid on being penetrated with a hot needle. It is generally brittle; but, on rubbing it with the nail, it becomes smooth like hard soap. Its colour is either white, black, ash-coloured, yellow, or blackish: or it is variegated, namely, grey with black specks, or grey with yellow specks. Its smell is peculiar, and not easy to be counterfeited. At 144° it melts, and at 212° is volatilised in the form of a white vapour. But, on a red-hot coal, it burns, and is entirely dissipated. Water has no action on it; acids, except nitric, act feebly on it; alkalis combine with it, and form a soap; ether and the volatile oils dissolve it; so do the fixed oils, and also ammonia, when assisted by heat; alcohol dissolves a portion of it, and is of great use in analyzing it, by separating its constituent parts. According to Bouillon la Grange, who has given the latest analysis of it, 3820 parts of ambergris consist of adipocere 2016 parts, a resinous substance 1167, benzoic acid 425, and coal 212. But Bucholz could find no benzoic acid in it. I examined two different specimens with considerable attention. The one yielded benzoic acid, the other, equally genuine to all appearance, afforded none. See ADIPOCERE and INTESTINAL CONCRETION.

An alcoholic solution of ambergris, added in minute quantity to lavender water, tooth powder, hair powder, wash balls, &c. communicates its peculiar fragrance. Its retail price being in London so high as a guinea per oz. leads to many adulterations. These consist of various mixtures of benzoin, labdanum, meal, &c. scented with musk. The greasy appearance and smell which heated ambergris exhibits, afford good *criteria*, joined to its solubility in hot ether and alcohol.

It has occasionally been employed in medicine, but its use is now confined to the perfumer. Dr. Swediaur took thirty grains of it without perceiving any sensible effect.

AMBLYGONITE. A greenish-coloured mineral of different pale shades, marked on the surface with reddish and yellowish-brown spots. It occurs massive and crystallized in oblique four-sided prisms. Lustre vitreous; cleavage parallel with the sides of an oblique four-sided prism of 106° 10′ and 77° 50′; fracture uneven; fragments rhomboidal; translucent; hardness, as felspar; brittle; sp. gr. 3.0. Intumesces with the blowpipe, and fuses with a reddish-yellow phosphorescence into a white enamel. It occurs in granite, along with green topaz and tourmaline, near Pinig in Saxony. It seems to be a species of spodumene.

AMBREINE. By digesting ambergris in hot alcohol, sp. gr. 0.827, the peculiar substance called *ambreine* by Pelletier and Caventon is obtained. The alcohol, on cooling, deposits the ambreine in very bulky and irregular crystals, which still retain a very considerable portion of alcohol. Thus obtained, it has the following properties: It is of a brilliant white colour, has an agreeable odour, of which it is deprived by repeated solutions and crystallizations. It is destitute of taste, and does not act on vegetable blues. It is insoluble in water, but dissolves readily in alcohol and ether; and in much greater quantity in these liquids, when hot, than when cold. It melts at the temperature of 86°, softening at 77°. It is partly volatilized and decomposed into a white smoke when heated above 212°. It does not seem capable of combining with an alkali, or of being saponified. When heated with nitric acid, it becomes green and then yellow, while nitrous gas is exhaled. By this absorption of oxygen, it is converted into an acid, which has been called *ambreic* acid. This acid is yellowish white, has a peculiar smell, reddens vegetable blues, does not melt at 212°, and evolves no ammonia when decomposed at higher temperatures. It is soluble in alcohol and ether; but slightly so in water. Ambreate of potash gives yellow precipitates with muriate of lime, muriate of barytes, sulphate of copper, sulphate of iron, nitrate of silver, acetate of lead, corrosive sublimate, muriate of tin, and muriate of gold. *Journ. de Pharm.* v. 49.

AMETHYST. The amethyst is a gem of a violet colour, and great brilliancy, said to be as hard as the ruby or sapphire, from which it only differs in colour. This is called the oriental amethyst, and is very rare. When it inclines to the purple or rosy colour, it is more esteemed than when it is nearer to the blue. These amethysts have the same figure, hardness, specific gravity, and other qualities, as the best sapphires or rubies, and come from the same places, particularly from Persia, Arabia, Armenia, and the West Indies. The occidental amethysts are merely coloured crystal or quartz. See QUARTZ and SAPPHIRE.

AMIANTHOIDE. A mineral, in long capillary filaments, of an olive green colour, flexible and elastic. Lustre, brilliant silky. It is composed of silica 47; lime 11; magnesia 7; oxide of iron 20; manganese 10. *Vauquelin*. It is found at Oisans in France. *Phillips's Mineralogy.*

AMIANTHUS, mountain flax. See ASBESTUS.

AMIATITE. FIORITE, or PEARLSINTER.

AMIDINE. This is a substance produced, according to M. de Saussure, when we abandon the paste of starch to itself, at the ordinary temperature, with or without the contact of air. See STARCH.

AMMONIA, called also volatile alkali. We shall first consider this substance in its purely scientific relations, and then detail its manufacture on the great scale, and its uses in the arts. There is a saline body, formerly brought from Egypt, where it was separated from soot by sublimation, but which is now made abundantly in Europe, called sal ammoniac. From this salt pure ammonia can be readily obtained by the following process: Mix unslaked quicklime with its own weight of sal ammoniac, each in fine powder, and introduce them into a glass retort. Join to the beak of the retort, by a collar of caoutchouc, (a neck of an India rubber bottle answers well), a glass tube about 18 inches long, containing pieces of ignited muriate of lime. This tube should lie in a horizontal position, and its free end, previously bent obliquely by the blowpipe, should dip into dry mercury in a pneumatic trough. A slip of porous paper, as an additional precaution, may be tied round the tube, and kept moist with ether. If a gentle heat from a charcoal chauffer or lamp be now applied to the bottom of the retort, a gaseous body will bubble up through the mercury. Fill a little glass tube, sealed at one end, with the gas, and transfer it, closely stopped at the other end, into a basin containing water. If the water rise instantly and fill the whole tube, the gas is pure, and may be received for examination.

Ammonia is a transparent, colourless, and consequently invisible gas, possessed of elasticity, and the other mechanical properties of the atmospherical air. Its specific gravity is an important *datum* in chemical researches, and has been rather differently stated. Yet, as no aeriform body is more easily obtained in a pure state than ammonia, this diversity among accurate experimentalists, shows the nicety of this statical operation. MM. Biot and Arago make it = 0.59669 by experiment, and by calculation from its elementary gases, they make it = 0.59438. Kirwan says, that 100 cubic inches weigh 18.16 gr. at 30 inches of bar. and 61° F. which compared to air reckoned 30.519, gives 0.59540. Sir H. Davy determines its density to be = 0.590, with which estimate the theoretic calculations of Dr. Prout, in the 6th volume of the Annals of Philosophy, agree.

This gas has an exceedingly pungent smell, well known by the old name of spirits of hartshorn. An animal plunged into it speedily dies. It extinguishes combustion, but being itself to a certain degree combustible, the flame of a taper immersed in it, is enlarged before going out. By exposing this gas to a very low temperature M. Bussy succeeded in liquifying it. See ACID (SULPHUROUS). It has a very acrid taste. Water condenses it very rapidly. The following valuable table of its aqueous combinations has been given by Sir H. Davy.

Sp. Gr.	*Ammonia.*	*Water.*
0.8750	32.50	67.50
0.8875	29.25	70.75
0.9000	26.00	74.00
0.9054	25.37	74.63
0.9166	22.07	77.93
0.9255	19.54	80.46
0.9326	17.52	82.48
0.9385	15.88	84.12
0.9435	14.53	85.47
0.9476	13.46	86.54
0.9513	12.40	87.60
0.9545	11.56	88.44
0.9573	10.82	89.18
0.9597	10.17	89.83
0.9619	9.60	90.40
0.9692	9.50	90.50

Water is capable of dissolving easily about one-third of its weight of ammoniacal gas, or 460 times its bulk. Hence, when placed in contact with a tube filled with this gas, water rushes into it with explosive velocity. Probably the quantity of ammonia stated in the above table is too high by about one per cent.

The following table of the quantity of ammonia in 100 parts, by weight, of its aqueous combinations at successive densities, was published by me in the Philosophical Magazine for March 1821.

Water of 0.900.	Ammonia in 100.	Water in 100.	Sp. gr. by experiment.	Mean specific gravity.	Equivalent primes.	
100	26.500	73.500	0.9000			
95	25.175	74.825	0.9045	0.90452		wat. amm.
90	23.850	76.150	0.9090	0.90909	24 + 76,	6 to 1
85	22.525	77.475	0.9133	0.91370		
80	21.200	78.800	0.9177	0.91838	21.25 + 78.75,	7 to 1
75	19.875	80.125	0.9227	0.92308		
70	18.550	81.450	0.9275	0.92780	19.1 + 80.9,	8 to 1
65	17.225	82.775.	0.9320	0.93264	17.35 + 82.65,	9 to 1
60	15.900	84.100	0.9363	0.93750	15.9 + 84.1	10 to 1
55	14.575	85.425	0.9410	0.94241	14.66 + 85.34,	11 to 1
50	13.250	86.750	0.9455	0.94737	13.60 + 86.40,	12 to 1
45	11.925	88.075	0.9510	0.95238	11.9 + 88.1,	14 to 1
40	10.600	89.400	0.9564	0.95744	11.2 + 88.8,	15 to 1
35	9.275	90.725	0.9614	0.96256		
30	7.950	92.050	0.9662	0.96774	8.63 + 91.37,	20 to 1
25	6.625	93.375	0.9716	0.97207	7 + 93,	25 to 1
20	5.300	94.700	0.9768	0.97626	6 + 94,	30 to 1
15	3.975	96.025	0.9828	0.98360	4.5 + 95.5	40 to 1
10	2.650	97.350	0.9887	0.9890	3 + 97,	60 to 1
5	1.325	98.675	0.9945	0.99447		

The remarkable expansiveness which ammonia carries into its first condensation with water, continues in the subsequent dilutions of its aqueous combinations. This curious property is not peculiar to pure ammonia, but belongs, as I have found, to some of its salts. Thus sal ammoniac, by its union with water, causes an enlargement of the total volume of the compound, beyond the volume of the constituents of the solution. Or the specific gravity of the saturated solution is less than the mean sp. gravity of the salt and water. I know of no salts with which this phenomenon occurs, except the ammoniacal.

Near the two extremities of the table, the experimental and computed specific gravities agree; the reciprocal affinity thus balancing the peculiar expansiveness communicated by the ammonia, which becomes conspicuous in the intermediate proportions of water and gas. This fact is in unison with the general laws of chemical combination.

Since 73.5 grains of distilled water exist in 100 water of ammonia, specific gravity 0.900, which occupy the volume of 1.111, one part of water in bulk will be converted into almost exactly one and a half of such water of ammonia. 100 grains of this water contain 147.2 cubic inches of gas. Hence 1 *grain* of water holds condensed in such aqueous ammonia 2 cubic inches of the gas, or one *volume* of distilled water is united to 505 volumes of gas.

It is a remarkable coincidence, that one volume of water, when converted into aqueous muriatic acid, specific gravity 1.200, or into aqueous ammonia, sp. grav. 0.900, expands in either case into a volume and a half.

If from 998 we deduct the specific gravity of water of ammonia, expressed in three integers, the remainder, divided by 4, will give a quotient representing the quantity of real alkali present. This rule is exact for all such liquid ammonia as is commonly used in chemical researches and in medicine, viz. between sp. gravities 936 and 980, water being 1000.

Liquid ammonia, as the aqueous compound is termed, may therefore like spirits be very accurately valued by its specific gravity. But it differs remarkably from alcoholic mixtures in this respect, that the strongest ammoniacal liquor, when it is diluted with water, suffers little condensation of volume. The specific gravity of the dilute, is not far from that of its components. Hence having one point accurately, we can compute all below it, by paying attention to the rule given under Specific Gravity. To procure aqueous ammonia, we may use either a common still and refrigeratory or a Woolfe's apparatus. The latter should be preferred. Into a retort we put a mixture of two parts of slaked lime, and one part of pulverized sal ammoniac, and having connected the beak of the retort with the Woolfe's apparatus, containing pure water, we then disengage the ammonia, by the application of heat. When gas ceases to be evolved, the addition of a little hot water will renew its disengagement, and ensure complete decomposition of the salt. Since sal ammoniac contains nearly ⅓ its weight of ammonia, ten pounds of it should yield by economical treatment 30 pounds of liquid, whose specific gravity is 0.950, which is as strong as the ordinary purposes of chemistry and medicine require; and it will form twice that quantity, or 60 pounds of the common water of ammonia sold by apothecaries, which has rarely a smaller density than 0.978 or 0.980. There is no temptation to make it with the ammoniacal carbonate; but if this salt be accidentally present, it is instantly detected by its causing a milkiness in lime water.

Ammoniacal gas, perfectly dry when mixed with oxygen, explodes with the electric spark, and is converted into water and nitrogen, as has been shown in an ingenious paper by Dr. Henry. But the simplest, and perhaps most accurate mode of resolving ammonia into its elementary constituents, is that first practised by M. Berthollet, the celebrated discoverer of its composition. This consists in making the pure gas traverse very slowly an ignited porcelain tube of a small diameter. The process, as lately repeated by M. Gay Lussac, yielded from 100 cubic inches of ammonia, 200 cubic inches of constituent gases; of which, by subsequent analysis, 50 were found to be nitrogen, and 150 hydrogen. Hence we see, that the reciprocal affinity of the ammoniacal elements had effected a condensation equal to one-half of the volume of the free gases. It appears by the most recent determinations, that the specific gravity of hydrogen is 0.0694, compared to air as unity, and that of nitrogen 0.9722. Three volumes of the former will therefore weigh 0.2082, and one of the latter, 0.9722; the sum of which numbers, 1.1804, divided by 2, ought to coincide with the experimental density of ammonia. Now, it is 0.5902, being an exact correspondence. And the ratio of the two weights, reduced to 100 parts, will be 82.36 nitrogen to 17.64 hydrogen. To reduce ammonia to the system of equivalents, or to find its saturating ratio on that scale where oxygen represents unity, we have this proportion; 9722 : 1.75 : : 1.1804 : 2.125; so that 2.125 may be called its prime equivalent. We shall find this number deduced from analysis, confirmed by the synthesis of all the ammoniacal salts.

Dr. Prout, in an able memoir on the relation between the specific gravities of gaseous bodies, and the weights of their atoms, published in the 6th vol. of the Annals of Philosophy, makes the theoretical weight of the atom of ammonia to be only 1.9375, considering it as a compound of 1 atom of azote, and 1½ atoms of hydrogen. This statement appears to be a logical inference from Mr. Dalton's hypothesis of atomical combination. For water, the great groundwork of his atomic structure, is represented as a compound of one atom of oxygen with one atom of hydrogen; and this atomical unit of hydrogen consists of two volumes of the gas. Hence three volumes of the gas must represent an atom and a half. But an atom is, by its very definition, indivisible. Dr. Prout, in the 38th number of the Annals, restores the true proportions of 3 atoms hydrogen + 1 azote. Our doctrine of equivalent primes, resting on the basis of experimental induction, claims no knowledge of the atomical constitution of bodies.

The alkaline nature of ammonia is demonstrated, not only by its neutralizing acidity, and changing the vegetable reds to purple or green, but also by its being attracted to the negative pole of a voltaic arrangement. When a pretty strong electric power is applied to ammonia in its liquid or solid combinations, simple decomposition is effected; but in contact with mercury, very mysterious phenomena occur. If a globule of mercury be surrounded with a little water of ammonia, or placed in a little cavity in a piece of sal ammoniac, and then subjected to the voltaic power by two wires, the negative touching the mercury, and the positive the ammoniacal compound, the globule is instantly covered with a circulating film, a white smoke rises from it, and its volume enlarges, whilst it shoots out ramifications of a semi-solid consistence over the salt. The amalgam has the consistence of soft butter, and may be cut with a knife. Whenever the electrization is suspended, the crab-like fibres retract towards the central mass, which soon, by the constant formation of white saline films, resumes its pristine globular shape and size. The enlargement of volume seems to amount occasionally to ten times that of the mercury, when a small globule is employed. Sir H. Davy, Berzelius, and MM. Gay Lussac, and Thenard, have studied this singular phenomenon with great care. They produced the very same substance by putting an amalgam of mercury and potassium into the moistened cupel of sal ammoniac. It becomes five or six times larger, assumes the consistence of butter, whilst it retains its metallic lustre.

What takes place in these experiments? In the second case, the substance of metallic aspect which we obtain is an ammoniacal hydruret of mercury and potassium. There is formed, besides, muriate of potash. Consequently a portion of the potassium of the amalgam decomposes the water, becomes potash, which itself decomposes the muriate of ammonia. Thence result hydrogen and ammonia, which, in the nascent state, unite to the undecomposed amalgam. In the first experiment, the substance which, as in the second, presents the metallic aspect, is only an ammoniacal hydruret of mercury; its formation is accompanied by the perceptible evolution of a certain quantity of chlorine at the positive pole. It is obvious, therefore, that the salt is decomposed by the electricity. The hydrogen of the muriatic acid, and the ammonia, both combine with the mercury. These hydrurets possess the following properties:—

Their sp. gravity is in general below 3.0; exposed for some time to the temperature of 32° F. they assume considerable hardness, and crystallize in cubes, which are often as beautiful and large as those of bismuth. Ether and alcohol instantly destroy these amalgams, exciting a brisk effervescence with them, and reproducing the pure mercurial globule. These amalgams are slightly permanent in the air, if undisturbed; but the least agitation is fatal to their existence. MM. Gay Lussac and Thenard found, by immersion in water, that mercury, in passing to the state of a hydruret, absorbed 3½ times its volume of hydrogen. The ammoniacal hydruret of mercury and potassium may exist by itself; but as soon as we attempt to separate or oxidize the potassium, its other constituent principles also separate. Hence this hydruret is speedily decomposed by the air, by oxygen gas, and in general by all bodies that act upon potassium. It is even affected by mercury, so that in treating it with this metal, we may easily determine the relative quantity of ammonia and hydrogen which it contains. We need only for this purpose take up the interior parts of the hydruret with a little iron spoon, fill up with it a little glass tube, already nearly full of mercury; and closing this with a very dry stopper, invert it in mercury equally dry. The hydruret will rise to the upper part of the tube, will be decomposed, especially by a slight agitation, and will give out hydrogen and ammonia in the ratio of 1 to 2.5.

The mere ammoniacal hydrurets contain but a very small quantity of hydrogen and ammonia. By supposing that, in the ammoniacal hydruret of mercury, the hydrogen is to the ammonia in the same proportion as in the ammoniacal hydruret of mercury and potassium, it will appear that the first is formed, in volume, of 1 of mercury, 3.47 hydrogen, and 8.67 ammoniacal gas, at the mean pressure and temperature of 30. and 60°; or in weight, of about 1800 parts of mercury, with 1 part of hydrogen, and 1 of ammonia.

Ammonia is not affected by a cherry-red heat. According to Guyton de Morveau, it becomes a liquid at about 40°—0°, or at the freezing point of mercury; but it is uncertain whether the appearances he observed may not have been owing to hygrometric water, as happens with chlorine gas. The ammoniacal liquid loses its pungent smell as its temperature sinks, till at —50° it gelatinizes, if suddenly cooled; but if slowly cooled, it crystallizes.

Oxygen, by means of electricity, or a mere red heat, resolves ammonia into water and nitrogen. When there is a considerable excess of oxygen, it acidifies a portion of the nitrogen into nitrous acid, whence many fallacies in analysis have arisen. Chlorine and ammonia exercise so powerful an action on each other, that when mixed suddenly, a sheet of white flame pervades them. The simplest way of making this fine experiment, is to invert a matrass, with a wide mouth and conical neck, over another with a taper neck, containing a mixture of sal ammoniac and lime, heated by a lamp. As soon as the upper vessel seems to be full of ammonia, by the overflow of the pungent gas, it is to be cautiously lifted up, and inserted, in a perpendicular direction, into a wide-mouthed glass decanter or flask, filled with chlorine. On seizing the two vessels thus joined with the two hands covered with gloves, and suddenly inverting them, like a sand-glass, the heavy chlorine and light ammonia, rushing in opposite directions, unite with the evolution of flame. As one volume of ammonia contains, in a condensed state, one and a half of hydrogen, which requires for its saturation just one and a half of chlorine, this quantity should resolve the mixture into muriatic acid and nitrogen, and thereby give a ready analysis of the alkaline gas. If the proportion of chlorine be less, sal ammoniac and nitrogen are the results. The same thing happens on mixing the aqueous solutions of ammonia and chlorine. But if large bubbles of chlorine be let up in ammoniacal water of moderate strength, luminous streaks are seen in the dark to pervade the liquid, and the same reciprocal change of the ingredients is effected.

MM. Gay Lussac and Thenard state that when three parts of ammoniacal gas and one of chlorine are mixed together, they condense into sal ammoniac, and azote equal to 1-10th the whole volume is given out. This result is at variance with their own theory of volumes.

Three of ammoniacal gas consist of 4½ hydrogen, and 1½ nitrogen in a condensed state; 1 of chlorine seizes 1 of hydrogen, to form 2 of muriatic acid gas, which precipitate with 2 of ammonia, in a pulverulent muriate. But the third volume of ammonia had parted with 1 volume of its hydrogen to the chlorine, and another half-volume of hydrogen will unite with 0.166 of a volume of nitrogen, to form $\frac{0.66}{2} = 0.33$ of redundant ammonia, while 0.33 of a volume of nitrogen is left unemployed. Hence 2-3ds of a volume, or 1-6th of the original bulk of the mixed gases, ought to remain; consisting of equal parts of ammonia and nitrogen, instead of 1-10th of azote, as the French chemists state.

Iodine has an analogous action on ammonia; seizing a portion of its hydrogen to form hydriodic acid, whence hydriodate of ammonia results; while another portion of iodine unites with the liberated nitrogen, to form the explosive pulverulent iodide.

Cyanogen and ammoniacal gas begin to act upon each other whenever they come into contact, but some hours are requisite to render the effect complete. They unite in the proportion nearly of 1 to 1½, forming a compound which gives a dark orange brown colour to water, but dissolves in only a very small quantity of water. The solution does not produce prussian blue with the salts of iron.

By transmitting ammoniacal gas through charcoal ignited in a tube, prussic or hydrocyanic acid is formed.

The action of the alkaline metals on gaseous ammonia is very curious. When potassium is fused in that gas, a very fusible olive-green substance, consisting of potassium, nitrogen, and ammonia, is formed; and a volume of hydrogen remains, exactly equal to what would result from the action on water of the quantity of potassium employed. Hence, according to M. Thenard, the ammonia is divided into two portions. One is decomposed, so that its nitrogen combines with the potassium, and its hydrogen remains free, whilst the other is absorbed in whole or in part by the nitroguret of potassium. Sodium acts in the same manner. The olive substance is opaque, and it is only when in plates of extreme thinness that it appears semitransparent; it has nothing of the metallic appearance; it is heavier than water; and on minute inspection seems imperfectly crystallized. When it is exposed to a heat progressively increased, it melts, disengages ammonia, and hydrogen, and nitrogen, in the proportions constituting ammonia; then it becomes solid, still preserving its green colour, and is converted into a nitroguret of potassium or sodium. Exposed to the air at the ordinary temperature, it attracts only its humidity, but not its oxygen, and is slowly transformed into ammoniacal gas, and potash or soda. It burns vividly when projected into a hot crucible, or when heated in a vessel containing oxygen. Water and acids produce also sudden decomposition, with the extrication of heat. Alkalis or alkaline salts are produced. Alcohol likewise decomposes it with similar results. The preceding description of the compound of ammonia with potassium, as prepared by MM. Gay Lussac and Thenard, was controverted by Sir H. Davy.

The experiments of this accurate chemist led to the conclusion, that the presence of moisture had modified their results. In proportion as more precautions are taken to keep every thing absolutely dry, so in proportion is less ammonia regenerated. He seldom obtained as much as 1-10th of the quantity absorbed;

and he never could procure hydrogen and nitrogen in the proportions constituting ammonia; there was always an excess of nitrogen. The following experiment was conducted with the utmost nicety. 3½ gr. of potassium were heated in 12 cubic inches of ammoniacal gas; 7.5 were absorbed, and 3.2 of hydrogen evolved. On distilling the olive-coloured solid in a tube of platina, 9 cubical inches of gas were given off, and half a cubical inch remained in the tube and adapters. Of the 9 cubical inches, one-fifth of a cubical inch only was ammonia; 10 measures of the permanent gas mixed with 7.5 of oxygen, and acted upon by the electrical spark, left a residuum of 7.5. He infers that the results of the analysis of ammonia, by electricity and potassium, are the same.

On the whole we may legitimately infer, that there is something yet unexplained in these phenomena. The potassium separates from ammonia as much hydrogen as an equal weight of it would from water. If two volumes of hydrogen be thus detached from the alkaline gas, the remaining volume, with the volume of nitrogen, will be left to combine with the potassium, forming a triple compound, somewhat analogous to the cyanides, a compound capable of condensing ammonia. For an account of a singular combination of ammonia, by which its volatility seems destroyed, see CHLORINE.

When ammoniacal gas is transmitted over ignited wires of iron, copper, platina, &c. it is decomposed completely, and though the metals are not increased in weight, they have become extremely brittle. Iron, at the same temperature, decomposes the ammonia, with double the rapidity that platinum does. At a high temperature, the protoxide of nitrogen decomposes ammonia.

Of the ordinary metals, zinc is the only one which liquid ammonia oxidizes and then dissolves. But it acts on many of the metallic oxides. At a high temperature the gas deoxidizes all those which are reducible by hydrogen. The oxides soluble in liquid ammonia are, the oxide of zinc, the protoxide and peroxide of copper, the oxide of silver, the third and fourth oxides of antimony, the oxide of tellurium, the protoxides of nickel, cobalt, and iron, the peroxide of tin, mercury, gold, and platinum. The first five are very soluble, the rest less so. These combinations can be obtained by evaporation, in the dry state, only with copper, antimony, mercury, gold, platinum, and silver; the four last of which are very remarkable for their detonating property. See the particular metals.

All the acids are susceptible of combining with ammonia, and they almost all form with it neutral compounds. M. Gay Lussac made the important discovery, that whenever the acid is gaseous, its combination with ammoniacal gas takes place in a simple ratio of determinate volumes, whether a neutral or a subsalt be formed.

AMMONIACAL SALTS have the following general characters—

1st, When treated with a caustic fixed alkali or earth, they exhale the peculiar smell of ammonia.

2d, They are generally soluble in water, and crystallizable.

3d, They are all decomposed at a moderate red heat; and if the acid be fixed, as the phosphoric or boracic, the ammonia comes away pure.

4th, When they are dropped into a solution of muriate of platina, a yellow precipitate falls.

1. *Acetate.* This saline compound was formerly called the spirit of Mindererus, who introduced it into medicine as a febrifuge sudorific. By saturating a pretty strong acetic acid with subcarbonate of ammonia, enclosing the liquid under the receiver of an air-pump, along with a saucerful of sulphuric acid, and exhausting the air, the salt will concrete in acicular crystals, which are nearly neutral. It may also be made very conveniently, by mixing hot saturated solutions of acetate of lead, and sulphate of ammonia, taking 100 of the first salt in its ordinary state to 34.4 of the second, well dried at a heat of 212°. Or even muriate of ammonia will answer in the proportion of 27.9 to 100 of the acetate. Acetate of ammonia has a cooling sweetish taste. It is deliquescent, and volatile at all temperatures; but it sublimes in the solid state at 250°. It consists of 75⅓ of dry acetic acid, and 24⅔ ammonia. When intended for medicine, it should always be prepared from pure acetic acid, and subcarbonate of ammonia.

Arseniate of ammonia may be formed by saturating the arsenic acid with ammonia, and evaporating the liquid. Crystals of a rhomboidal prismatic form are obtained. A binarseniate may also be made by using an excess of acid. At a red heat, the ammonia of both salts is decomposed, and the acid is reduced to the metallic state. Under the respective acids, an account of several ammoniacal salts will be found. As the muriate, however, constitutes an extensive manufacture, we shall enter here into some additional details concerning its production.

Sal ammoniac was originally fabricated in Egypt. The dung of camels and other animals constitutes the chief fuel used in that country. The soot is carefully collected. Globular glass vessels, about a foot in diameter, are filled within a few inches of their mouth with it, and are then arranged in an oblong furnace, where they are exposed to a heat gradually increased. The upper part of the glass balloon stands out of the furnace, and is kept relatively cool by the air. On the 3d day the operation is completed, at which time they plunge an iron rod occasionally into the mouths of the globes, to prevent them from closing up, and thus endanger the bursting of the glass.

The fire is allowed to go out; and on breaking the cooled globes, their upper part is found to be lined with sal ammoniac in hemispherical lumps, about 2½ inches thick, of a greyish-white colour, semitransparent, and possessed of a degree of elasticity. 26 pounds of soot yield 6 of sal ammoniac. The ordinary mode of manufacturing sal ammoniac in Europe, is by combining with muriatic acid the ammonia resulting from the igneous decomposition of animal matters in close vessels. Cylinders of cast iron, fitted up as we have described under ACETIC ACID, are charged with bones, horns, parings of hides, and other animal matters; and being exposed to a full red heat, an immense quantity of an impure liquid carbonate of ammonia distils over. Mr. Minish contrived a cheap method of converting this liquid into sal ammoniac. He digested it with pulverized gypsum, or simply made it percolate through a stratum of bruised gypsum; whence resulted a liquid sulphate of ammonia, and an insoluble carbonate of lime. The liquid, evaporated to dryness, was mixed with muriute of soda, put into large glass balloons, and decomposed by a subliming heat. Sal ammoniac was found above in its characteristic cake, while sulphate of soda remained below.

M. Leblanc of St. Denis, near Paris, invented another method of much ingenuity, which is described by a commission of eminent French chemists in the 19th volume of the Annales de Chimie, and in the Journal de Physique for the year 1794. He used tight brick kilns, instead of iron cylinders, for holding the materials to be decomposed. Into one he put a mixture of common salt and oil of vitriol; into another, animal matters. Heat extricated from the first muriatic acid gas, and from the second ammonia; which bodies being conducted by their respective flues into a third chamber lined with lead, and containing a stratum of water on its bottom, entered into combination, and precipitated in solid sal ammoniac on the roof and sides, or in liquid at the bottom.

In the 20th volume of the Annales, a plan for employing bittern or muriate of magnesia to furnish the acid ingredient is described. An ingenious process on the same principles was some time ago commenced at Borrowstouness in Scotland, by Mr. Astley. He imbued in a stove-room, heated by brick flues, parings of skins, horns, and other animal matters, with the muriate of magnesia, or mother water of the sea-salt works. The matters thus impregnated and dried were subjected in a close kiln to a red heat, when the sal ammoniac vapour sublimed, and was condensed either in a solid form, into an adjoining chamber or chimney, or else into a stratum of water on its bottom. Muriate of magnesia at a red heat evolves muriatic acid gas; an evolution probably aided in the present case by the affinity of ammonia.

From coal soot likewise a considerable quantity of ammonia, in the state of carbonate and sulphate, may be obtained, either by sublimation or lixiviation with water. These ammoniacal products can afterwards be readily converted into the muriate, as above described. M. Leblanc used a kettle or eolipile for projecting steam into the leaden chamber, to promote the combination. It is evident, that the exact neutralization essential to sal ammoniac might not be hit at first in these operations; but it could be afterwards affected by the separate addition of a portion of alkaline or acid gas. As the mother waters of the Cheshire salt-works contain only 3⅓ per cent. of muriate of magnesia, they are not suitable, like those of sea-salt works, for the above manufacture. See SALT.

AMMONIAC (GUM). This is a gum resin, which consists, according to Braconnot, of 70 resin, 18.4 gum, 4.4 glutinous matter, 6 water, and 1.2 loss in 100 parts. It forms a milky solution with water; is partially soluble in alcohol; entirely in ether, nitric acid, and alkalies. Sp. gr. 1.200. It has rather a heavy smell, and a bitter-sweet taste. It is in small agglutinated pieces of a yellowish-white colour. It is used in medicine as an expectorant and antispasmodic.

AMMONITES. These petrifactions, which have likewise been distinguished by the name of *cornua ammonis*, and are called *snake-stones* by the vulgar, consist chiefly of lime-stone. They are found of all sizes, from the breadth of half an inch to more than two feet in diameter; some of them rounded, others greatly compressed, and lodged in different strata of stones and clays. They appear to owe their origin to shells of the nautilus kind.

AMOMUM. See PIMENTO.

AMPELITE. The aluminous ampelite, is the alum slate, and the graphic, the graphic slate.

AMPHIBOLE. See HORNBLENDE and ACTYNOLITE.

AMPHIBOLITES. In geology, trap rocks, the basis of which is amphibole or hornblende.

AMPHIGENE. See VESUVIAN.

AMYGDALOID. A compound mineral, consisting of spheroidal particles or vesicles of lithomarge, green earth, calc spar, steatite, imbedded in a basis of fine-grained green stone, or wacke, containing sometimes also crystals of hornblende,

AMYLINE or AMYDINE. Saussure exposed a solution of starch in twelve times its weight of water to the air in a shallow capsule for two years. It had then become a grey liquid, covered with mould, free from smell, and without action on vegetable blue colours.

The starch had lost nearly one-fourth of its weight, and the remainder was converted into the following substances. 1, Sugar, amounting to one half of the starch; 2, gum, or a substance analogous to it, obtained by roasting starch; 3, amyline; 4, starchy lignine; 5, lignine mixed with charcoal. Amyline is intermediate between gum and starch. It is soluble in boiling water, and the solution affords by evaporation a pale semi-transparent brittle substance, insoluble in alkohol, but soluble in ten times its weight of cold water, and to any extent in water at 144°. The solution becomes a white paste, with subacetate of lead. With iodine it becomes blue. It is precipitated by barytes water, but not by lime water, potash, soda, or galls. *Phil. Trans.* 1819.

ANACARDIUM, cashew nut, or marking nut. At one extremity of the fruit of the cashew tree is a flattish kidney-shaped nut, between the rind of which and the thin outer shell is a small quantity of a red, thickish, inflammable, and very caustic liquor. This liquor forms an useful marking ink, as any thing written on linen or cotton with it is of a brown colour, which gradually grows blacker, and is very durable.

ANALCIME. Cubic zeolite. This mineral is generally found in aggregated or cubic crystals, whose solid angles are replaced by three planes. External lustre between vitreous and pearly; fracture, flat conchoidal; colours, white, grey, or reddish; translucent. From its becoming *feebly* electrical by heat it has got the name analcime. Its sp. gr. is less than 2.6. It consists of 58 silica, 18 alumina, 2 lime, 10 soda, 8½ water, and 3½ loss in 100 parts. It is found in granite, gneiss, trap rocks and lavas, at Calton Hill Edinburgh, at Talisker in Sky, in Dumbartonshire, in the Hartz, Bohemia, and at the Ferroe Islands. The variety found at Somma has been called sarcolite, from its flesh colour.

ANALYSIS. Chemical analysis consists of a great variety of operations, performed for the purpose of separating the component parts of bodies. In these operations the most extensive knowledge of such properties of bodies as are already discovered must be applied, in order to produce simplicity of effect, and certainty in the results. Chemical analysis cannot be executed with success, by one who is not in possession of a considerable number of simple substances in a state of great purity, which, from their effects, are called reagents. The word analysis is applied by chemists to denote that series of operations by which the component parts of bodies are determined, whether they be merely separated, or exhibited apart from each other; or whether these distinctive properties be exhibited by causing them to enter into new combinations. The forming of new combinations is called synthesis; and, in the chemical examination of bodies, analysis or separation can scarcely ever be effected, without synthesis taking place at the same time.

As most of the improvements in the science of chemistry consist in bringing the art of analysis nearer to perfection, it is not easy to give any other rule to the learner than the general one of consulting and remarking the processes of the best chemists, such as Scheele, Bergman, Klaproth, Kirwan, Vauquelin, and Berzelius. The bodies which present themselves more frequently for examination than others are minerals and mineral waters. In the examination of the former, it was the habit of the earlier chemists to avail themselves of the action of fire, with very few humid processes, which are such as might be performed in the usual temperature of the atmosphere. Modern chemists have improved the process by fire, by a very extensive use of the blowpipe (see BLOWPIPE); and have succeeded in determining the component parts of minerals to great accuracy in the humid way. For the method of analyzing mineral waters, see WATERS (MINERAL); and for the analysis of metallic ores, see ORES.

Several authors have written on the examination of earths and stones.

The first step in the examination of consistent earths or stones is somewhat different from that of such as are pulverulent. Their specific gravity should first be examined; also their hardness, whether they will strike fire with steel, or can be scratched by the nail, or only by crystal, or stones of still greater hardness: also their texture, perviousness to light, and whether they be manifestly homogeneous or compound species, &c.

2*d*, In some cases, we should try whether they imbibe water, or whether water can extract any thing from them by ebullition or digestion.

3*d*, Whether they be soluble in, or effervesce with acids, before or after pulverization; or whether decomposable by boiling in a strong solution of potash, &c., as gypsums and ponderous spars are.

4*th*, Whether they detonate with nitre.

5*th*, Whether they yield the fluor acid by distillation with sulphuric acid, or ammonia by distilling them with potash.

6*th*, Whether they be fusible *per se* with a blowpipe, and how they are affected by soda, borax, and microcosmic salt; and whether they decrepitate when gradually heated.

7*th*, Stones that melt *per se* with the blowpipe are certainly compound, and contain at least three species of earth, of which the calcareous is probably one; and if they give fire with steel, the siliceous is probably another.

The general process prescribed by the celebrated Vauquelin, in the 30th volume of the Annales de Chimie, is the clearest which has yet been offered to the chemical student.

If the mineral be very hard, it is to be ignited in a covered crucible of platinum, and then plunged into cold water, to render it brittle and easily pulverizable. The weight should be noted before and after this operation, in order to see if any volatile matter has been emitted. For the purpose of reducing stones to an impalpable powder, little mortars of highly hardened steel are now made, consisting of a cylindrical case and pestle. A mortar of agate is also used for subsequent levigation. About ten grains of the mineral should be treated at once; and after the whole 100 grains have been reduced in succession to an impalpable powder, they should be weighed, to find what increase may have been derived from the substance of the agate. This addition may be regarded as silica.

Of the primary earths, only four are usually met with in minerals, viz. silica, alumina, magnesia, and lime, associated with some metallic oxides, which are commonly iron, manganese, nickel, copper, and chromium.

If neither acid nor alkali be expected to be present, the mineral is mixed in a silver crucible, with thrice its weight of pure potash and a little water. Heat is gradually applied to the covered crucible, and is finally raised to redness; at which temperature it ought to be maintained for an hour. If the mass, on inspection, be a perfect glass, silica may be regarded as the chief constituent of the stone; but if the vitrification be very imperfect, and the bulk much increased, alumina may be supposed to predominate. A brownish or dull green colour indicates the presence of iron; a bright grass-green, which is imparted to water, that of manganese; and from a greenish-yellow, chromium may be expected. The crucible, still a little hot, being first wiped, is put into a capsule of porcelain or platinum; when warm distilled water is poured upon the alkaline earthy mass, to detach it from the crucible. Having transferred the whole of it into the capsule, muriatic acid is poured on, and a gentle heat applied, if necessary, to accomplish its solution. If the liquid be of an orange-red colour, we infer the presence of iron; if of a golden-yellow, that of chromium; and if of a purplish-red, that of manganese. The solution is next to be evaporated to dryness, on a sand bath, or over a lamp, taking care so to regulate the heat that no particles be thrown out. Towards the end of the evaporation, it assumes a gelatinous consistence. At this period it must be stirred frequently with a platinum spatula or glass rod, to promote the disengagement of the muriatic acid gas. After this, the heat may be raised to fully 212° F. for a few minutes. Hot water is now to be poured on in considerable abundance, which dissolves every thing except the silica. By filtration, this earth is separated from the liquid; and being edulcorated with hot water, it is then dried, ignited, and weighed. It constitutes a fine white powder, insoluble in acids, and feeling gritty between the teeth. If it be coloured, a little dilute muriatic acid must be digested on it, to remove the adhering metallic particles, which must be added to the first solution. This must now be reduced by evaporation to the bulk of half a pint. Carbonate of potash being then added, till it indicates alkaline excess, the liquid must be made to boil for a little. A copious precipitation of the earth and oxides is thus produced. The whole is thrown on a filter, and after it is so drained as to assume a semi-solid consistence, it is removed by a platinum blade, and boiled in a capsule for some time, with solution of pure potash. Alumina and glucina are thus dissolved, while the other earths and the metallic oxides remain.

This alkalino-earthy solution, separated from the rest by filtration, is to be treated with an excess of muriatic acid; after which carbonate of ammonia being added also in excess, the alumina is thrown down while the glucina continues dissolved. The first earth separated by filtration, washed, dried, and ignited, gives the quantity of alumina. The nature of this may be further demonstrated, by treating it with dilute sulphuric acid, and sulphate of potash, both in equivalent quantities, when the whole will be converted into alum. (See ALUM). The filtered liquid will deposit its glucina, on dissipating the ammonia, by ebullition. It is to be separated by filtration, to be washed, ignited, and weighed.

The matter undissolved by the digestion of the liquid potash may consist of lime, magnesia, and metallic oxides. Dilute sulphuric acid must be digested on it for some time. The solution is to be evaporated to dryness, and heated to expel the excess of acid. The saline solid matter being now diffused in a moderate quantity of water, the sulphate of magnesia will be dissolved, and, along with the metallic sulphates, may be separated from the sulphate of lime by the filter. The latter being washed with a little water, dried, ignited, and weighed, gives, by the scale of equivalents, the quantity of lime in the mineral. The magnesian and metallic solution being diluted with a large quantity of water is to be treated with bicarbonate of potash, which will precipitate the nickel, iron, and chromium, but retain the magnesia and manganese, by the excess of carbonic acid. Hydrosulphuret of potash will throw down the manganese, from the magnesian solution. The addition of pure potash, aided by gentle ebullition, will then precipitate the magnesia. The oxide of manganese may be freed from the sulphuretted hydrogen, by ustulation.

The mingled metallic oxides must be digested with abundance of nitric acid, to acidify the chromium. The liquid is next treated with potash, which forms a soluble chromate, while it throws down the iron and nickel. The chromic acid may be separated from the potash by muriatic acid, and digestion with heat, washed, dried till it become a green oxide, and weighed. The nickel is separated from the iron, by treating their solution in muriatic acid, with water of ammonia. The latter oxide which falls may be separated by the filter, dried and weighed. By evaporating the liquid, and exposing the dry residue to a moderate heat the ammoniacal salt will sublime, and leave the oxide of nickel behind. The whole separate weights must now be collected in one amount, and if they constitute a sum within two per cent. of the primitive weight, the analysis may be regarded as giving a satisfactory account of the composition of the mineral. But if the deficiency be considerable, then some volatile ingredient, or some alkali or alkaline salt, may be suspected.

A portion of the mineral broken into small fragments, is to be ignited in a porcelain retort, to which a refrigerated receiver is fitted. The water or other volatile and condensable matter, if any be present, will thus be obtained. But if no loss of weight be sustained by ignition, alkali, or a volatile acid, may be looked for. The latter is usually the fluoric. It may be expelled by digestion with sulphuric acid. It is exactly characterized by its property of corroding glass.

Beside this general method, some others may be used in particular cases.

Thus, to discover a small proportion of alumina or magnesia in a solution of a large quantity of lime, pure ammonia may be applied, which will precipitate the alumina or magnesia (if any be), but not the lime. Distilled vinegar applied to the precipitate will discover whether it be alumina or magnesia.

2*dly*, A minute portion of lime or barytes, in a solution of alumina or magnesia, may be discovered by the sulphuric acid, which precipitates the lime and barytes: the solution should be dilute, else the alumina also would be precipitated. If there be not an excess of acid, the oxalic acid is still a nicer test of lime: 100 grains of gypsum contain about 33 of lime; 100 grains of sulphate of barytes contain 66 of barytes; 100 grains of oxalate of lime contain 43.8 of lime. The insolubility of sulphate of barytes in 500 times its weight of boiling water sufficiently distinguishes it. From these data the quantities are easily investigated.

3*dly*, A minute proportion of alumina in a large quantity of magnesia may be discovered, either by precipitating the whole, and treating it with distilled vinegar; or by heating the solution nearly to ebullition, and adding more carbonate of magnesia, until the solution is perfectly neutral, which it never is when alumina is contained in it, as this requires an excess of acid to keep it in solution. By these means the alumina is precipitated in the state of embryon alum, which contains about half its weight of alumina, (or, for greater exactness, it may be decomposed by boiling it in volatile alkali). After the precipitation the solution should be largely diluted, as the sulphate of magnesia, which remained in solution while hot, would precipitate when cold, and mix with the embryon alum.

4*thly*, A minute portion of magnesia in a large quantity of alumina is best separated by precipitating the whole, and treating the precipitate with distilled vinegar.

Lastly, Lime and barytes are separated by precipitating both with the sulphuric acid, and evaporating the solution to a small compass, pouring off the liquor, and treating the dried precipitate with 500 times its weight of boiling water; what remains undissolved is sulphate of barytes.

The inconveniences of employing much heat are obvious, and Mr. Lowitz informs us that they may be avoided without the least disadvantage. Over the flame of a spirit lamp, that will hold an ounce and half, and is placed in a cylindrical tin furnace, four inches high and three in diameter, with air-holes, and a cover perforated to hold the crucible, he boils the stone prepared as directed above, stirring it frequently. His crucible, which, as well as the spatula, is of very fine silver, holds two ounces and a half, or three ounces. As soon as the matter is boiled dry, he pours in as much hot water as he used at first; and this he repeats two or three times more, if the refractoriness of the fossil require it. Large tough bubbles arising during the boiling are in general a sign that the process will be attended with success. Even the sapphire, though the most refractory of all Mr. Lowitz tried, was not more so in this than in the dry way.

Sir H. Davy observes, that boracic acid is very useful in analyzing stones that contain a fixed alkali; as its attraction for the different earths at the heat of ignition is considerable, and the compounds it forms with them are easily decomposed by the mineral acids, dissolved in water. His process is as follows: Let 100 grains of the stone to be examined be reduced to a fine powder, mixed with 200 grains of boracic acid, and fused for about half an hour at a strong red heat in a crucible of platina or silver. Digest the fused mass in an ounce and half of nitric acid, diluted with seven or eight times the quantity of water, till the whole is decomposed; and then evaporate the solution till it is reduced to an ounce and half, or two ounces. If the stone contained silex, it will separate in this process, and must be collected on a filter, and edulcorated with distilled water, to separate the saline matter. The fluid, mixed with all the water that has been passed through the filter, being evaporated till reduced to about half a pint, is to be saturated with carbonate of ammonia, and boiled with an excess of this salt, till all that will precipitate has fallen down. The earths and metallic oxides being separated by filtration, mix nitric acid with the clear fluid till it has a strongly sour taste, and then evaporate till the boracic acid remains free. Filter the fluid, evaporate it to dryness, and expose it to a heat of 450° F. when the nitrate of ammonia will be decomposed, and the nitrate of potash or soda will remain in the vessel. The earths and metallic oxides, that remained on the filter, may be distinguished by the common processes. The alumina may be separated by solution of potash, the lime by sulphuric acid, the oxide of iron by succinate of ammonia, the manganese by hydrosulphuret of potash, and the magnesia by pure soda.

Lately carbonate or nitrate of barytes, and carbonate with nitrate of lead, have been introduced into mineral analysis with great advantage, for the fluxing of stones that may contain alkaline matter. See the English Translation of M. Thenard's volume on analysis.

M. Berzelius has more recently employed fluoric acid in a very ingenious manner for the analysis of siliceous minerals. In extracting lithia, for example, from triphane or spodumene, he mixes the mineral in powder, with twice its weight of pulverized fluor spar, and with sulphuric acid; he then heats the mixture so that the fluoric acid shall carry off the silica in the form of fluo-silicic acid gas, and he afterwards separates the sulphate of lithia from the residuary matter by solution.

Under the head of mineral analysis, nothing is of so much general importance as the examination of soils, with a view to the improvement of such as are less productive, by supplying the ingredients they want in due proportions to increase their fertility. To Lord Dundonald and Mr. Kirwan we are much indebted for their labours in this field of inquiry; but Sir H. Davy, assisted by the labours of these gentlemen, the facts and observations of Mr. Young, and his own skill in chemistry, having given at large, in a manner best adapted for the use of the practical farmer, an account of the methods to be pursued for this purpose, we shall here copy them.

The substances found in soils are certain mixtures or combinations of some of the primitive earths, animal and vegetable matter in a decomposing state, certain saline compounds, and the oxide of iron. These bodies always retain water, and exist in very different proportions in different lands, and the end of analytical experiments is the detection of their quantities and mode of union.

The earths commonly found in soils are principally silex, or the earth of flints; alumina, or the pure matter of clay; lime, or calcareous earth; and magnesia: for the characters of which see the articles. Silex composes a considerable part of hard gravelly soils, hard sandy soils, and hard stony lands. Alumina abounds most in clayey soils, and clayey loams; but even in the smallest particles of these soils it is generally united with silex and oxide of iron. Lime always exists in soils in a state of combination, and chiefly with carbonic acid, when it is called carbonate of lime. This carbonate in its hardest state is marble; in its softest, chalk. Lime united with sulphuric acid is sulphate of lime, or gypsum; with phosphoric acid, phosphate of lime, or the earth of bones. Carbonate of lime, mixed with other substances, composes chalky soils and marles, and is found in soft sandy soils. Magnesia is rarely found in soils; when it is, it is combined with carbonic acid, or with silex and alumina. Animal decomposing matter exists in different states, contains much carbonaceous substance, volatile alkali, inflammable aëriform products, and carbonic acid. It is found chiefly in lands lately manured. Vegetable decomposing matter usually contains still more carbonaceous substance, and differs from the preceding, principally in not producing volatile alkali. It forms a great proportion of all peats, abounds in rich mould, and is found in larger or smaller quantities in all lands. The saline compounds are few, and in small quantity: they are chiefly muriate of soda, or common salt, sulphate of magnesia, muriate and sulphate of potash, nitrate of lime, and the mild alkalis. Oxide of iron, which is the same with the rust produced by exposing iron to air and water, is found in all soils, but most abundantly in red and yellow clays, and red and yellow siliceous sands.

The instruments requisite for the analysis of soils are few. A pair of scales capable of holding a quarter of a pound of common soil, and turning with a single grain when loaded: a set of weights from a quarter of a pound troy to a grain: a wire sieve, coarse enough to let a peppercorn pass through: an Argand lamp and stand: a few glass bottles, Hessian crucibles, and china or queen's ware evaporating basins: a Wedgwood pestle and mortar: some filters made of half a sheet of blotting paper, folded so as to contain a pint of liquid, and greased at the edges: a bone knife; and an apparatus for collecting and measuring aëriform fluids.

The reagents necessary are muriatic acid, sulphuric acid, pure volatile alkali dissolved in water, solution of prussiate of potash, soap lye, and solutions of carbonate of ammonia, muriate of ammonia, neutral carbonate of potash, and nitrate of ammonia.

1. When the general nature of the soil of a field is to be ascertained, specimens of it should be taken from different places, two or three inches below the surface, and examined as to the similarity of their properties. It sometimes happens, that on plains the whole of the upper stratum of the land is of the same kind, and in this case one analysis will be sufficient.

But in valleys, and near the beds of rivers, there are very great differences, and it now and then occurs, that one part of a field is calcareous, and another part siliceous; and in this and analagous cases, the portions different from each other should be analyzed separately. Soils when collected, if they cannot be examined immediately, should be preserved in phials quite filled with them, and closed with ground glass stopples. The most convenient quantity for a perfect analysis is from two hundred grains to four hundred. It should be collected in dry weather, and exposed to the air till it feels dry. Its specific gravity may be ascertained, by introducing into a phial, which will contain a known quantity of water, equal bulks of water and of the soil; which may easily be done, by pouring in water till the phial is half full, and then adding the soil till the fluid rises to the mouth. The difference between the weight of the water, and that of the soil, will give the result. Thus if the bottle will contain four hundred grains of water, and gains two hundred grains when half filled with water and half with soil, the specific gravity of the soil will be 2; that is, it will be twice as heavy as water: and if it gained one hundred and sixty-five grains, its specific gravity would be 1825, water being 1000. It is of importance that the specific gravity of a soil should be known, as it affords an indication of the quantity of animal and vegetable matter it contains, these substances being always most abundant in the lighter soils. The other physical properties of soils should likewise be examined before the analysis is made, as they denote, to a certain extent, their composition, and serve as guides in directing the experiments. Thus siliceous soils are generally rough to the touch, and scratch glass when rubbed upon it: aluminous soils adhere strongly to the tongue, and emit a strong earthy smell when breathed upon; and calcareous soils are soft, and much less adhesive than aluminous soils.

2. Soils, when as dry as they can be made by exposure to the air, still retain a considerable quantity of water, which adheres with great obstinacy to them, and cannot be driven off without considerable heat: and the first process of analysis is to free them from as much of this water as possible, without affecting their composition in other respects. This may be done by heating the soil for ten or twelve minutes in a china basin over an Argand lamp, at a temperature equal to 300° F.; and if a thermometer be not used, the proper degree of heat may easily be ascertained by keeping a piece of wood in the basin in contact with its bottom; or as long as the colour of the wood remains unaltered, the heat is not too high; but as soon as it begins to be charred, the process must be stopped. In several experiments, in which Sir H Davy collected the water that came over at this degree of heat, he found it pure, without any sensible quantity of other volatile matter being produced. The loss of weight in this process must be carefully noted; and if it amount to 50 grains in 400 of the soil, this may be considered as in the greatest degree absorbent and retentive of water, and will generally be found to contain a large proportion of aluminous earth: if the loss be not more than 10 or 20 grains, the land may be considered as slightly absorbent and retentive, and the siliceous earth as most abundant.

3. None of the loose stones, gravel, or large vegetable fibres, should be separated from the soil, till the water is thus expelled; for these bodies are often highly absorbent and retentive, and consequently influence the fertility of the land. But after the soil has been heated as above, these should be separated by the sieve, after the soil has been gently bruised in a mortar. The weights of the vegetable fibres or wood, and of the gravel and stones, should be separately noted down, and the nature of the latter ascertained: if they be calcareous, they will effervesce with acids; if siliceous, they will scratch glass; if aluminous, they will be soft, easily scratched with a knife, and incapable of effervescing with acids.

4. Most soils, besides stones and gravel, contain larger or smaller proportions of sand of different degrees of fineness; and the next operation necessary is to separate this sand from the parts more minutely divided, such as clay, loam, marl, and vegetable and animal matter. This may be done sufficiently by mixing the soil well with water; as the coarse sand will generally fall to the bottom in the space of a minute, and the finer in two or three; so that by pouring the water off after one, two, or three minutes, the sand will be for the most part separated from the other substances; which, with the water containing them, must be poured into a filter. After the water has passed through, what remains on the filter must be dried and weighed; as must also the sand; and their respective quantities must be noted down. The water must be preserved, as it will contain the saline matter, and the soluble animal or vegetable matter, if any existed in the soil.

5. A minute analysis of the sand thus separated is seldom or never necessary, and its nature may be detected in the same way as that of the stones and gravel. It is always siliceous sand, or calcareous sand, or both together. If it consist wholly of carbonate of lime, it will dissolve rapidly in muriatic acid with effervescence; but if it consists partly of this and partly of siliceous matter, a residuum will be left after the acid has ceased to act on it, the acid being added till the mixture has a sour taste, and has ceased to effervesce. This residuum is the siliceous part; which being washed, dried, and heated strongly in a crucible, the difference of its weight from that of

the whole, will indicate the quantity of the calcareous sand.

6. The finely divided matter of the soil is usually very compound in its nature; it sometimes contains all the four primitive earths of soils, as well as animal and vegetable matter; and to ascertain the proportions of these with tolerable accuracy is the most difficult part of the subject. The first process to be performed in this part of the analysis is the exposure of the fine matter of the soil to the action of muriatic acid. This acid, diluted with double its bulk of water, should be poured upon the earthy matter in an evaporating basin, in a quantity equal to twice the weight of the earthy matter. The mixture should be often stirred, and suffered to remain for an hour, or an hour and half, before it is examined. If any carbonate of lime, or of magnesia, exist in the soil, they will have been dissolved in this time by the acid, which sometimes takes up likewise a little oxide of iron, but very seldom any alumina. The fluid should be passed through a filter; the solid matter collected, washed with distilled or rain water, dried at a moderate heat, and weighed. Its loss will denote the quantity of solid matter taken up. The washings must be added to the solution; which, if not sour to the taste, must be made so by the addition of fresh acid; and a little solution of prussiate of potash must be mixed with the liquor. If a blue precipitate occur, it denotes the presence of oxide of iron, and the solution of the prussiate must be dropped in, till no further effect is produced. To ascertain its quantity, it must be collected on a filter in the same manner as the other solid precipitates, and heated red: the result will be oxide of iron. Into the fluid freed from oxide of iron, a solution of carbonate of potash must be poured, till all effervescence ceases in it, and till its taste and smell indicate a considerable excess of alkaline salt. The precipitate that falls down is carbonate of lime, which must be collected on a filter, dried at a heat below that of redness, and afterward weighed. The remaining fluid must be boiled for a quarter of an hour, when the magnesia, if there be any, will be precipitated combined with carbonic acid, and its quantity must be ascertained in the same manner as that of the carbonate of lime. If any minute proportion of alumina should, from peculiar circumstances, be dissolved by the acid, it will be found in the precipitate with the carbonate of lime, and it may be separated from it by boiling for a few minutes with soap lye sufficient to cover the solid matter: for this lye dissolves alumina, without acting upon carbonate of lime. Should the finely divided soil be sufficiently calcareous to effervesce very strongly with acids, a simple method of ascertaining the quantity of carbonate of lime, sufficiently accurate in all common cases, may be adopted. As carbonate of lime in all its states contains a determinate quantity of acid, which is about 44 parts in a hundred by weight, the quantity of this acid given out during the effervescence occasioned by its solution in a stronger acid will indicate the quantity of carbonate of lime present. Thus, if you weigh separately one part of the matter of the soil, and two parts of the acid diluted with an equal quantity of water, and mix the acid slowly in small portions with the soil, till it ceases to occasion any effervescence, by weighing the mixture, and the acid that remains, you will find the quantity of carbonic acid lost; and for every four grains and half so lost, you will estimate ten grains of carbonate of lime. You may also collect the carbonic acid in the *pneumatic apparatus for the analysis of soils*, described in the article LABORATORY; and allow for every ounce measure of the carbonic acid, two grains of carbonate of lime.

7. The quantity of insoluble animal and vegetable matter may next be ascertained with sufficient precision, by heating it to a strong red heat in a crucible over a common fire, till no blackness remains in the mass, stirring it frequently meanwhile with a metallic wire. The loss of weight will ascertain the quantity of animal and vegetable matter there was, but not the proportions of each. If the smell emitted, during this process, resemble that of burnt feathers, it is a certain indication of the presence of some animal matter; and a copious blue flame almost always denotes a considerable proportion of vegetable matter. Nitrate of ammonia, in the proportion of twenty grains to a hundred of the residuum of the soil, will greatly accelerate this process, if the operator be in haste; and not affect the result, as it will be decomposed and evaporate.

8. What remains after this decomposition of the vegetable and animal matter consists generally of minute particles of earthy matter, which are usually a mixture of alumina and silex with oxide of iron. To separate these, boil them two or three hours in sulphuric acid diluted with four times its weight of water, allowing a hundred and twenty grains of acid for every hundred grains of the residuum.

If any thing remain undissolved by this acid, it may be considered as silex, and be separated, washed, dried, and weighed in the usual manner. Carbonate of ammonia being added to the solution in quantity more than sufficient to saturate the acid, the alumina will be precipitated; and the oxide of iron, if any, may be separated from the remaining liquid by boiling it. It scarcely ever happens that any magnesia or lime escapes solution in the muriatic acid; but if it should, it will be found in the sulphuric acid; from which it may be separated as directed above for the muriatic. This method of analysis is sufficiently precise for all common purposes; but if very great accuracy be an object, the residuum after the incineration must be treated with potash, and in the manner in which stones are analyzed, as given in the first part of this article.

9. If the soil contained any salts, or soluble vegetable or animal matter, they will be found in the water used for separating the sand. This water must be evaporated to dryness at a heat below boiling. If the solid matter left be of a brown colour, and inflammable, it may be considered as partly vegetable extract. If its smell, when exposed to heat, be strong and fetid, it contains animal, mucilaginous, or gelatinous matter. If it be white and transparent, it may be considered as principally saline. Nitrate of potash or of lime is indicated in this saline matter by its sparkling when thrown on burning coals: sulphate of magnesia may be detected by its bitter taste; and sulphate of potash produces no alteration in a solution of carbonate of ammonia, but precipitates a solution of muriate of barytes.

10. If sulphate or phosphate of lime be suspected in the soil, a particular process is requisite to detect it. A given weight of the entire soil, as four hundred grains for instance, must be mixed with one-third as much powdered charcoal, and kept at a red heat in a crucible for half an hour. The mixture must then be boiled a quarter of an hour in half a pint of water, and the solution, being filtered, exposed some days to the open air. If any notable quantity of sulphate of lime, or gypsum, existed in the soil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion.

Phosphate of lime, if any be present, may be separated from the soil after the process for gypsum. Muriatic acid must be digested upon the soil in quantity more than sufficient to saturate the soluble earths. The solution must be evaporated, and water poured upon the solid matter. This fluid will dissolve the compounds of earths with the muriatic acid, and leave the phosphate of lime untouched.

11. When the examination of a soil is completed, the products should be classed, and their quantities added together; and if they nearly equal the original quantity of soil, the analysis may be considered as accurate. It must however be observed, that when phosphate or sulphate of lime is discovered by the independent process, No. 10, just mentioned, a correction must be made for the general process by subtracting a sum equal to their weight from the quantity of carbonate of lime obtained by precipitation from the muriatic acid. In arranging the products, the form should be in the order of the experiments by which they are obtained. Thus 400 grains of a good siliceous sandy soil may be supposed to contain—

		grains.
Of water of absorption, . . .		18
Of loose stones and gravel, principally siliceous, ...		42
Of undecompounded vegetable fibres, .		10
Of fine siliceous sand, . . .		200
Of minutely divided matter, separated by filtration, and consisting of—		
Carbonate of lime, . . .	25	
Carbonate of magnesia, . .	4	
Matter destructible by heat, principally vegetable, . .	10	
Silex, ...	40	
Alumina, ...	32	
Oxide of iron, . . .	4	
Soluble matter, principally sulphate of potash and vegetable extract, ...	5	
Gypsum, ...	3	
Phosphate of lime, . . .	2	
	—	125
Amount of all the products,		395
Loss, ...		5
		400

In this instance the loss is supposed small; but in general, in actual experiments, it will be found much greater, in consequence of the difficulty of collecting the whole quantities of the different precipitates; and when it is within thirty for four hundred grains, there is no reason to suspect any want of due precision in the processes.

12. When the experimenter is become acquainted with the use of the different instruments, the properties of the reagents, and the relations between the external and chemical qualities of soils, he will seldom find it necessary to perform, in any one case, all the processes that have been described. When his soil, for instance, contains no notable proportion of calcareous matter, the action of the muriatic acid, No. 6. may be omitted: in examining peat soils, he will principally have to attend to the operation by fire and air, No. 7.; and in the analysis of chalks and loams, he will often be able to omit the experiment with sulphuric acid, No. 8.

In the first trials that are made by persons unacquainted with chemistry, they must not expect much precision of result. Many difficulties will be met with; but in overcoming them the most useful kind of practical knowledge will be obtained; and nothing is so instructive in experimental science as the detection of mistakes. The correct analyst ought to be well grounded in general chemical information; but perhaps there is no better mode of gaining it than that of attempting original investigations. In pursuing his experiments, he will be continually obliged to learn from books the history of the substances he is employing or acting upon; and his theoretical ideas will be more valuable in being connected with practical operation, and acquired for the purpose of discovery.

The *analysis of vegetables* requires various manipulations, and peculiar attention, as their principles are extremely liable to be altered by the processes to which they are subjected. It was long before this analysis was brought to any degree of perfection.

Some of the immediate materials of vegetables are separated to our hands by Nature in a state of greater or less purity, as the gums, resins, and balsams, that exude from plants. The expressed juices contain various matters, that may be separated by the appropriate reagents. Maceration, infusion, and decoction in water, take up certain parts soluble in this menstruum; and alcohol will extract others that water will not dissolve. The mode of separating and distinguishing these materials will easily be collected from their characters, as given under the head VEGETABLE KINGDOM, and under the different articles themselves.

As the ultimate constituents of all vegetable substances are carbon, hydrogen, and oxygen, with occasionally azote, the problem of their final analysis resolves into a method of ascertaining the proportion of these elementary bodies. MM. Gay Lussac and Thenard contrived a very elegant apparatus for vegetable and animal analysis, in which the matter in a dried state was mixed with chlorate of potash, and formed into minute pellets. These pellets being projected through the intervention of a stop-cock of peculiar structure into an ignited glass tube, were instantly resolved into carbonic acid and water. The former product was received over mercury, and estimated by its condensation with potash; the latter was intercepted by ignited muriate of lime, and was measured by the increase of weight which it communicates to this substance. By previous trials, the quantity of oxygen which a given weight of the chlorate of potash yielded by ignition was known; and hence the carbon, hydrogen, and oxygen, derived from the organic substance, as well as the residual azote, of the gaseous products.

M. Berzelius modified the above apparatus, and employed the organic product in combination with a base, generally oxide of lead. He mixed a certain weight of this neutral compound with a known quantity of pure chlorate of potash, and triturated the whole with a large quantity of muriate of soda, for the purpose of moderating the subsequent combustion. This mingled dry powder is put into a glass tube about half an inch diameter, and eight or ten inches long, which is partially enclosed in a fold of tin-plate, hooped with iron wire. One end of the tube is hermetically sealed beforehand, the other is now drawn to a pretty fine point by the blowpipe. This termination is inserted into a glass globe about an inch diameter, which joins it to a long tube containing dry muriate of lime in its middle, and dipping at its other extremity into the mercury of a pneumatic trough. The first tube, with its protecting tin case, being exposed gradually to ignition, the enclosed materials are resolved into carbonic acid, water, and azote, which come over, and are estimated as above described. M. Gay Lussac has more recently employed peroxide of copper to mix with the organic substance to be analyzed; because while it yields its oxygen to hydrogen and carbon, it is not acted on by azote; and thus the errors resulting from the formation of nitric acid with the chlorate of potash are avoided. Berzelius has afforded satisfactory evidence by his analyses, that the simple apparatus which he employed is adequate to every purpose of chemical research. Dr. Prout has described, in the Annals of Philosophy for March 1820, a very neat form of apparatus for completing analysis of organic substances with the heat of a lamp. Hydrogen having the power in minute quantities of modifying the constitution of the organic bodies, requires to be estimated with corresponding minuteness. Mr. Porrett has very ingeniously suggested, that its quantity may be more accurately determined by the proportion of oxide of copper that is revived, than by the product of water. Dilute sulphuric acid being digested on the residual cupreous powder will instantly dissolve the oxide, and leave the reduced metal; whose weight will indicate, by the scale of equivalents, the hydrogen expended in its reduction. One of hydrogen corresponds to 9 of water, and to 32 of copper.

From my experiments, I find that this proposal of Mr. Porrett will not suit in practice, for much of the peroxide of copper is occasionally reduced merely to the state of protoxide.

Under the different vegetable and animal products, we shall take care to state their ultimate constituents by the most correct and recent analysis. The peculiar substances which water, alcohol, ether, and other solvents, can separate from an organic body, may be called the immediate products of the vegetable or animal kingdom; while the carbon, hydrogen, oxygen, and azote, discoverable by igneous analysis, are the ultimate constituent elements. To the former class belong sugar, gum, starch, oils, resins, gelatin, urea, organic acids, and alkalies, &c. which see.

The following account of my mode of executing the ultimate analysis of organic products is extracted from a paper which the Royal Society did me the honour to insert in their Transactions for 1822.

The improvements lately introduced into the analysis of vegetable and animal compounds, with the investigation of the equivalent ratios, in which their constituent elements, carbon, hydrogen, oxygen, and azote are associated, have thrown an unexpected light into this formerly obscure province of chemical science. While the substitution by M. Gay Lussac, of black oxide of copper for the chlorate of potash, has given peculiar facility and elegance to *animal* analysis, it may be doubted whether, in those cases where the main object of inquiry is the proportion of carbon, it has not, frequently, led to fallacious results. As the quantity of this element is inferred from the volume of carbonic acid evolved in the decomposition of the organic matters, such of their particles as happen not to be in immediate contact with the cupreous oxide, will remain unconverted into carbonic acid; and thus the proportion of carbon will come to be underrated; an accident which cannot occur with chlorate of potash, since the carbonaceous matter is here plunged in an ignited atmosphere of oxygen. It is probably to this cause that we must refer the discrepant results in the analysis of pure sugar, between MM. Gay Lussac, Thenard, and Berzelius, on the one hand, and Dr. Prout, on the other; the former gentlemen assigning about 43 parts in the hundred of carbon, while the latter states the carbon at only 40.

The objects of the present paper are, first, to indicate, and endeavour to remove several sources of fallacy attending the method with peroxide of copper; and next, to exhibit the results of its application to a considerable series of vegetable and animal compounds.

Peroxide of copper, prepared by igniting the pure nitrate of this metal, is, like yellow oxide of lead, and many other metallic oxides, readily absorbent of a small portion of humidity from the air, the quantity of which depends, in some measure, on the length of time during which it has suffered ignition. If exposed to a red heat, merely till the vapours of nitric acid are expelled, 100 grains of the oxide will absorb, in the ordinary state of the atmosphere, from one-tenth to two-tenths of a grain of moisture in the space of an hour or two; and about one-half of the above quantity in a very few minutes. The French chemists, who have operated most with this agent, seem to be well aware of this circumstance, for they direct the peroxide to be used immediately after ignition, and to be triturated with the organic matter in a hot mortar of agate or glass. Yet this precaution will not entirely prevent the fallacy arising from the hygrometric action; for I find that peroxide thus treated does absorb, during the long trituration essential to the process, a certain quantity of moisture, which, if not taken into account, will produce serious errors in the analytical results. It is better therefore to leave the powdered peroxide intended for research exposed for such time to the air as to bring it to hygrometric repose, then to put it up in a phial, and by igniting one hundred grains of it in a proper glass tube, sealed at one end, and loosely closed with a glass plug at the other, to determine the proportion of moisture which it contains. This, then, indicates the constant quantity to be deducted from the loss of weight which the peroxide suffers in the course of the experiment. The mortar should be perfectly dry, but not warm.

Experimenters have been at great pains to bring the various organic objects of research to a state of thorough desiccation before mixing them with the peroxide of copper; but this practice introduces a similar fallacy to that above described. We ought, therefore, after having made them as dry as possible by the joint agencies of heat, and an absorbent surface of sulphuric acid *in vacuo*, to expose them to the air till they also come into hygrometric repose, noting the quantity of moisture which they imbibe, that it may be afterwards allowed for. The plan which I adopt for the purpose of desiccation seems to answer very well. Having put the pulverulent animal or vegetable matter into short phials, furnished with ground glass stoppers, I place the open phials in a large quantity of sand, heated to 212° F. in a porcelain capsule, and set this over a surface of sulphuric acid in an exhausted receiver. After an hour or more the receiver is removed, and the phials instantly stopped. The loss of weight shows the total moisture which each of them has parted with; while the subsequent increase of their weight, after leaving them unstopped for some time in the open air, indicates the amount of hygrometric absorption. This is consequently the quantity to be deducted in calculating experimental results.

Many chemists, particularly in this country, have employed the heat of a spirit-lamp, instead of that produced by the combustion of charcoal, for igniting the tube in which the mixed materials are placed. I have compared very carefully both methods of heating, and find that for many bodies, such as coal and resin, which abound in carbon, the flame of the lamp is insufficient; while its application being confined at once to a small portion of the tube, that uniform ignition of the whole, desirable towards the close of the experiment, cannot be obtained. I was hence led to contrive a peculiar form of furnace, in which, with a handful of charcoal, reduced to bits about the size of small filberts, an experiment may be completed without anxiety or trouble, in the space of half an hour. Since I have operated with this instrument, the results on the same body have been much more consistent than those previously obtained with the lamp; and it is so convenient, that I have sometimes finished eight experiments in a day.

Fig. 1. (Plate VI.) represents the whole apparatus, as when in action. Fig. 2. is a horizontal section of the furnace, in which we perceive a semi-cylinder of thin sheet-iron, about eight inches long and $3\frac{1}{2}$ wide, perforated with holes, and resting on the edge of a hollow prism of tin-plate, represented more distinctly in fig. 3. where *s* shows a slit, through which the sealed end of the glass tube may be made to project, on occasion. *i* is a handle attached to the semi-cylinder, by which it may be slid backwards or forwards, and removed at the end of the process. *d* is a sheath of platinum foil, which serves, by aid of a wire laid across, to support the middle of the tube, when it is softened by ignition. At *g*, the plates which close the ends of the semi-cylinder and tin-plate prism, rise up a few inches to screen the pneumatic apparatus from the heat. A third occasional screen of tin-plate is hung on at *f*. All these are furnished with slits for the passage of the glass tube. This is made of crown glass, and is generally about 9 or 10 inches long, and 3-10ths of internal diameter. It is connected with the mercurial cistern by a narrow tube and caoutchouc collar. This tube has a syphon form, and rises about an inch within the graduated receiver at *e*. By this arrangement, should the collar be not absolutely air-tight, the pressure of the column of mercury causes the atmospheric air to enter at the crevice, and bubbles of it will be seen rising up without the application of heat. At the end of the operation, the point of the tube *e* is always left above the surface of the mercury, the quantity of organic matter employed being such as to produce from 6 to 7 cubic inches of gaseous product, the volume of the graduated receiver being 7 cubic inches.

As the tubes with which I operate have all the same capacity, viz. half a cubic inch; and as the bulk of materials is the same in all the experiments, one experiment on the analysis of sugar or resin gives the volume of atmospheric air due to the apparatus; which volume is a constant quantity in the same circumstances of ignition. And since the whole apparatus is always allowed to cool to the atmospheric temperature, the volume of residual gas in the tubes comes to be exactly known, being equal, very nearly, to the primitive volume of atmospheric air left after the absorption of the carbonic acid in the sugar or resin experiment[*]. Thus this quantity, hitherto ill appreciated or neglected in many experiments, though it is of very great consequence, may be accurately found. At *k*, fig. 2. a little tin-plate screen is shown. It is perforated for the passage of the tube, and may be slid along, and left at any part of the semi-cylindric cage, so as to preserve from the influence of the heat any requisite portion of the sealed end of the tube. At fig. 4. is seen the shape of the little bulb, into which I introduce the proper weight of ether, alcohol, naphtha, or other volatile liquids, which are destined for analysis. After weighing it exactly, it is immediately slid down to the bottom of the tube, and covered with 150 or 200 grains of peroxide of copper. The bulb has a capacity equal to 3 grain measures of water, and its capillary point is sometimes closed with an inappreciably small quantity of bees-wax, to prevent the exhalation of the liquid, till the peroxide be ignited.

b is a cover to the furnace, with an oblong orifice at its top. It serves for a chimney, and may be applied or removed by means of its handle, according as we wish to increase or diminish the heat. *cc* are tin cases enclosing corks, through which the iron wires are passed, that support the whole furnace at any convenient height and angle of inclination.

The tightness of the apparatus at the end of the process is proved by the rising of the mercury in the graduated receiver, by about one tenth of an inch, as the tube becomes refrigerated.

My mode of operating with the peroxide of copper is the following:

I triturate very carefully in a dry glass mortar, from 1 to 2½ grains of the matter to be analyzed, with from 100 to 140 grains of the oxide. I then transfer it, by means of a platinum-foil tray and small glass funnel, into the glass tube, clearing out the mortar with a metallic brush. Over that mixture I put 20 or 30 grains of the peroxide itself, and next, 50 or 60 grains of clean copper filings. The remaining part of the tube is loosely closed with 10 or 12 grains of amianthus, by whose capillary attraction the moisture evolved in the experiment is rapidly withdrawn from the hot part of the tube, and the risk of its fracture thus completely obviated. The amianthus serves moreover as a plug, to prevent the projection of any minute particles of filings, or of oxide, when the filings are not present. The tube is now weighed in a very delicate balance, and its weight is written down. A little cork, channelled at its side, is next put into the tube, to prevent the chance of mercury being forced backwards into it, by any accidental cooling or condensation. The collar of caoutchouc is finally tied on, and the tube is placed, as is shown in fig. 2. but without the plate *k*, which is employed merely in the case of analyzing volatile liquids. A few fragments of ignited charcoal are now placed under the tube, at the end of the furnace next to the cistern, and the remaining space in the semi-cylinder is filled up with bits of cold charcoal. The top, *b*, may then be put in its place, when the operation will proceed spontaneously, the progressive advance of the ignition from one end to the other being proportioned to the expansion of glass, so that the tube very seldom cracks in the process. Indeed I have often used the same tube for a dozen experiments, in the course of which it became converted into *vitrite*, or Reaumur's porcelain.

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[*] If a be the capacity of the graduated receiver, and b the spare capacity of the tubes, then the above volume is $b - \frac{b}{a+b}$.

Since the evolved gas is saturated with moisture, I reduce it to the volume of dry gas, by help of the following table, computed by the well known formula from my table of the elastic force of steam, which the Royal Society did me the honour to publish in their Transactions for the year 1818.

Temperature.	Multiplier.	Temperature.	Multiplier.	Temperature.	Multiplier.
53° F.	0.9870	60° F.	0.9827	67° F.	97.79
54	0.9864	61	98.20	68	97.72
55	0.9858	62	98.13	69	97.65
56	0.9852	63	98.06	70	0.9758
57	0.9846	64	97.99	71	0.9751
58	0.9839	65	97.93	72	0.9743
59	0.9833	66	97.86	73	0.9735

In certain cases, where the quantity of hydrogen is small, or where, as in the example of indigo, its presence has been denied, I employ pulverulent protochloride of mercury (calomel) instead of peroxide of copper. The organic compound being intimately mixed with that powder, and gently heated, the muriatic acid gas obtained demonstrates the presence, though half of its volume will not give the total quantity, of hydrogen; for a proportion of this elementary body continues associated with oxygen in the state of water. Dry oxalate of lead, treated in this way, yields not the slightest trace of muriatic acid; for, on passing the disengaged gas through a dilute solution of nitrate of silver, no precipitation or even cloud of chloride is produced. But 5 grains of indigo, prepared from the deoxidized solution of the dyer's vat, and freed from its lime and resin by the successive application of dilute muriatic acid and alcohol, gave 5 cubic inches of muriatic acid gas when heated along with 150 grains of calomel. Here we have a quantity of gas equivalent to 2½ cubic inches of hydrogen. By means of peroxide of copper, however, nearly 4 times the above quantity of hydrogen may be obtained from the same weight of indigo.

I shall now give in detail one example of the mode of computing the relation of the constituents from the experimental results, and shall then state the other analyses in a tabular form, subjoining a few remarks on the habitudes of some peculiar bodies.

1.4 grains of sulphuric ether, specific gravity 0.70, being slowly passed in vapour from the glass bulb through 200 grains of ignited peroxide of copper, yielded 6.8 cubic inches of carbonic acid gas at 66° F. which are equivalent to 6.57128 of dry gas at 60°. This number being multiplied by 0.127 = the carbon in 1 cubic inch of the gas, the product 0.8345256, is the carbon in 1.4 grains of ether; and $0.8345256 \times \frac{8}{3} = 2.2254$ = the oxygen equivalent to the carbonic acid. The tube was found to have lost 4.78 grains in weight, 0.1 of which was due to the hygrometric moisture in the oxide, and 1.4 to the ether. The remainder, 3.28, is the quantity of oxygen abstracted from the oxide by the combustible elements of the ether. But of these 3.28 grains, 2.2254 went to the formation of the carbonic acid, leaving 1.0546 of oxygen, equivalent to 0.1318 of hydrogen. Hence, 1.4 ether, by this experiment, which is taken as the most satisfactory of a great number, seem to consist of

Carbon,	0.8345
Hydrogen,	0.1318
Water,	0.4337
	1.4000

And in 1 grain we shall have,—

Carbon,	0.5960	3 atoms	2.25	60.00
Hydrogen,	0.1330	4 atoms	0.50	13.33
Oxygen,	0.2710	1 atom	1.00	26.66
	1.0000		3.75	100.0

Or, 3 vols olef. gas = 3 × 0.9722 = 2.9166
2 vap. of water 2 × 0.625 = 1.25
4.1666

The proportion of the constituents of sulphuric ether, deduced by M. Gay Lussac from the experiments of M. Th. de Saussure, are 2 volumes olefiant gas + 1 volume vapour of water, which 3 volumes are condensed into 1 of vapour of ether, having a specific gravity = 2.58. The ether which I used had been first distilled off dry carbonate of potash, and then digested on dry muriate of lime, from which it was simply decanted, according to the injunction of M. de Saussure. Whether my ether contained more alcoholic matter than that employed by the Genevese philosopher, or whether the difference of result is to be ascribed to the difference in the mode of analysis, must be decided by future researches.

By analogous modes of reduction, the results were deduced from my experiments. I ought here to state, than in many cases the materials, after being ignited in the tube, and then cooled, were again triturated in the mortar, and subjected to a second ignition. Thus, none of the carbon could escape conversion into carbonic acid. I was seldom content with one experiment on a body: frequently six or eight were made.

ANATASE. Octohedrite, oxide of titanium, rutile, and titane rutile. This mineral shows a variety of colours by reflected light, from indigo-blue to reddish-brown. By transmitted light it appears greenish-yellow. It is found usually in small crystals, octohedrons, with isosceles triangular faces. Structure lamellar; it is semitransparent, or opaque, fragments splendent, adamantine, scratches glass, brittle, sp. gr. 3.85. It is a pure oxide of titanium. It has been found only in Dauphiny and Norway; and is a very rare mineral. It occurs in granite, gneiss, mica slate, and transition lime-stone.

ANDALUSITE. A massive mineral, of a flesh and sometimes rose-red colour. It is, however, occasionally crystallized in rectangular four-sided prisms, verging on rhomboids. The structure of the prisms is lamellar, with joints parallel to their sides. Translucent, scratches quartz; is easily broken; sp. gr. 3.165. Infusible by the blowpipe; in which respect it differs from felspar, though called felspath apyre by Hauy. It is composed of 52 alumina, 32 silica, 8 potash, 2 oxide of iron, and 6 loss. *Vauq.* It belongs to primitive countries, and was first found in Andalusia in Spain. It is found in mica slate in Aberdeenshire, and in the Isle of Unst; Dartmoor in Devonshire; in mica slate at Killiney, near Dublin, and at Douce Mountain, county Wicklow.

ANDREOLITE. See HARMOTOME.

ANHYDRITE. Anhydrous gypsum. There are six varieties of it.

1. Compact has various shades, of white, blue, and red; massive and kidney-shaped; dull aspect; splintery or conchoidal fracture; translucent on the edges: is scratched by fluor, but scratches calc spar; somewhat tough; specific gravity 2.850. It is dry sulphate of lime, with a trace of sea salt. It is found in the salt mines of Austria and Salzburg, and at the foot of the Harz mountains. 2. Granular, the scaly of Jameson, is found in massive concretions, of which the structure is confusedly foliated. White or bluish colour, of a pearly lustre; composition as above, with one per cent. of sea salt. It occurs in the salt mines of Halle; sp. gr. 2.957. 3. Fibrous. Massive; glimmering, pearly lustre; fracture in delicate parallel fibres; scarcely translucent; easily broken. Found at Halle, Ischel, and near Brunswick. 4. Radiated. Blue sometimes spotted with red; radiated, splendent fracture; partly splintery; translucent; not hard; sp. gr. 2.940. 5. Sparry, or cube spar. Milk-white colour, passing sometimes into greyish and reddish-white; short four-sided prisms, having two of the opposite sides much broader than the other two; and occasionally the lateral edges are truncated, whence results an eight-sided prism; lustre splendent, pearly. Foliated fracture. Threefold rectangular cleavage. Cubical fragments. Translucent. Scratches calc spar. Brittle. Sp. gr. 2.9. This is the muriacite of some writers. It is doubly refracting. It is said to contain 1 per cent. of sea salt. It is found at Bex in Switzerland, and Halle in the Tyrol. 6. Siliciferous, or vulpinite. Massive concretions of a laminated structure, translucent on the edges, splendent and brittle. Greyish-white, veined with bluish-grey. Sp. gr. 2.88. It contains eight per cent. silex. The rest is sulphate of lime. It is called by statuaries, Marmo bardiglio di Bergamo, and takes a fine polish. It derives its name from Vulpino in Italy, where it accompanies lime.

ANHYDROUS. Destitute of water.

ANIL, or NIL. This plant, from the leaves of which indigo is prepared, grows in America.

ANIMAL KINGDOM. Animal bodies may be considered as peculiar apparatus for carrying on a determinate series of chemical operations. Vegetables seem capable of operating with fluids only, and at the temperature of the atmosphere, as we have just noticed. But most animals have a provision for mechanically dividing solids by mastication, which answers the same purpose as grinding, pounding, or levigation does in our experiments; that is to say, it enlarges the quantity of surface to be acted upon by solvents. The process carried on in the stomach appears to be of the same kind as that which we distinguish by the name of digestion; and the bowels, whatever other uses they may serve, evidently form an apparatus for filtering or conveying off the fluids; while the more solid parts of the aliments, which are probably of such a nature as not to be rendered fluid, but by an alteration which would perhaps destroy the texture of the machine itself, are rejected as useless. When this filtered fluid passes into the circulatory vessels, through which it is driven with considerable velocity by the mechanical action of the heart, it is subjected not only to all those changes which the chemical action of its parts is capable of producing, but is likewise exposed to the air of the atmosphere in the lungs, into which that elastic fluid is admitted by the act of respiration. Here it undergoes a change of the same nature as happens to other combustible bodies when they combine with its vital part, or oxygen. This vital part becomes condensed, and combines with the blood, at the same time that it gives out a large quantity of heat, in consequence of its own capacity for heat being diminished. A small portion of azote likewise is absorbed, and carbonic acid is given out. Some curious experiments of Spallanzani show, that the lungs are not the sole organs by which these changes are effected. Worms, insects, shells of land and sea animals, egg shells, fishes, dead animals, and parts of animals, even after they have become putrid, are capable of absorbing oxygen from the air, and giving out carbonic acid. They deprive atmospheric air of its oxygen as completely as phosphorus. Shells, however, lose this property when their organization is destroyed by age. Amphibia, deprived of their lungs, lived much longer in the open air, than others in air destitute of oxygen. It is remarkable, that a larva, weighing a few grains, would consume almost as much oxygen in a given time as one of the amphibia a thousand times its bulk. Fishes, alive and dead, animals, and parts of animals, confined under water in jars, absorbed the oxygen of the atmospheric air over the water. Muscles, tendons, bones, brain, fat, and blood, all absorbed oxygen in different proportions, but the blood did not absorb most; and bile appeared not to absorb any.

It would lead us too far from our purpose, if we were to attempt an explanation of the little we know respecting the manner in which the secretions or combinations that produce the various animal and vegetable substances are effected, or the uses of those substances in the economy of plants and animals. Most of them are very different from any of the products of the mineral kingdom. We shall therefore only add, that these organized beings are so contrived, that their existence continues, and all their functions are performed, as long as the vessels are supplied with food or materials to occupy the place of such as are carried off by evaporation from the surface or otherwise, and as long as no great change is made, either by violence or disease, in those vessels, or the fluids they contain. But as soon as the entire process is interrupted in any very considerable degree, the chemical arrangements become altered, the temperature in land animals is changed, the minute vessels are acted upon and destroyed, life ceases, and the admirable structure, being no longer sufficiently perfect, loses its figure, and returns, by new combinations and decompositions, to the general mass of unorganized matter, with a rapidity which is usually greater the more elaborate its construction.

The parts of vegetable or animal substances may be obtained, for chemical examination, either by simple pressure, which empties the vessels of their contents; by digestion in water, or in other fluids, which dissolve certain parts, and often change their nature; by destructive distillation, in which the application of a strong heat alters the combination of the parts, and causes the new products to pass over into the receiver in the order of their volatility; by spontaneous decomposition or fermentation, wherein the component parts take a new arrangement, and form compounds which did not for the most part exist in the organized substance; or, lastly, the judicious chemist will avail himself of all these several methods singly, or in combination. He will, according to circumstances, separate the parts of an animal or vegetable substance by pressure, assisted by heat; or by digestion or boiling in various fluids added in the retort which contains the substance under examination. He will attend particularly to the products which pass over, whether they be permanently elastic, or subject to condensation in the temperatures we are able to produce. In some cases, he will suffer the spontaneous decomposition to precede the application of chemical methods; and in others he will attentively mark the changes which the products of his operations undergo in the course of time, whether in closed vessels, or exposed to the open air. Thus it is that, in surveying the ample field of nature, the philosophical chemist possesses numerous means of making discoveries, if applied with judgment and sagacity; though the progress of discovery, so far from bringing us nearer the end of our pursuit, appears continually to open new scenes, and, by enlarging our powers of investigation, never fails to point out additional objects of inquiry.

Animal and vegetable substances approach each other by insensible gradations; so that there is no simple product of the one which may not be found in greater or less quantity in the other. The most general distinctive character of animal substances is that of affording volatile alkali by destructive distillation. Some plants, however, afford it likewise. Neither contain it ready formed; but it appears to be produced by the combination of hydrogen and azote, during the changes produced either by fire, or by the putrefactive process. See AMMONIA.

Our knowledge of the products of the animal kingdom, by the help of chemical analysis, is not yet sufficiently matured to enable us to arrange them according to the nature of their component parts; which appear to consist chiefly of hydrogen, oxygen, carbon, and azote; and with these sulphur, phosphorus, lime, magnesia, and soda, are frequently combined in variable proportions.

The following are the peculiar chemical products of animal organization. Gelatin, albumen, fibrin, caseous matter, colouring matter of blood, mucus, urea, picromel, osmazome, sugar of milk, and sugar of diabetes. The compound animal products are the various solids and fluids, whether healthy or morbid, that are found in the animal body; such as muscle, skin, bone, blood, urine, bile, morbid concretions, brain, &c.

When animal substances are left exposed to the air, or immersed in water or other fluids, they suffer a spontaneous change, which is more or less rapid according to circumstances. The spontaneous change of organized bodies is distinguished by the name of fermentation. In vegetable bodies there are distinct stages or periods of this process, which have been divided into the vinous, acetous, and putrefactive fermentations. Animal substances are susceptible only of the two latter, during which, as in all other spontaneous changes, the combinations of chemical principles become in general more and more simple. There is no doubt but much instruction might be obtained from accurate observations of the putrefactive processes in all their several varieties and situations; but the loathsomeness and danger attending on such inquiries have hitherto greatly retarded our progress in this department of chemical science. See FERMENTATION (PUTREFACTIVE).

ANIME, improperly called gum anime, is a resinous substance imported from New Spain and the Brazils. There are two kinds, distinguished by the names of oriental and occidental. The former is dry, and of an uncertain colour, some specimens being greenish, some reddish, and some of the brown colour of myrrh. The latter is in yellowish-white, transparent, somewhat unctuous tears, and partly in larger masses, brittle, of a light pleasant taste, easily melting in the fire, and burning with an agreeable smell. Like resins, it is totally soluble in alcohol, and also in oil. Water takes up about 1-16th of the weight of this resin by decoction. The spirit, drawn off by distillation, has a considerable degree of the taste and flavour of the anime; the distilled water discovers on its surface some small portion of essential oil.

This resin is used by perfumers, and also in certain plasters, wherein it has been supposed to be of service in nervous affections of the head and other parts; but there are no reasons to think that, for medical purposes, it differs from common resins.

ANNEAL. We know too little of the arrangement of particles to determine what it is that constitutes or produces brittleness in any substance. In a considerable number of instances of bodies which are capable of undergoing ignition, it is found that sudden cooling renders them hard and brittle. This is a real inconvenience in glass, and also in steel, when this metallic substance is required to be soft and flexible. The inconveniencies are avoided by cooling them very gradually, and this process is called annealing. Glass vessels, or other articles, are carried into an oven or apartment near the great furnace, called the leer, where they are permitted to cool, in a greater or less time, according to their thickness and bulk. The annealing of steel, or other metallic bodies, consists simply in heating them, and suffering them to cool again, either upon the hearth of the furnace, or in any other situation where the heat is moderate, or at least the temperature is not very cold.

ANNOTTO. The pellicles of the seeds of the *bixa orellana*, a liliaceous shrub, from 15 to 20 feet high in good ground, afford the red masses brought into Europe under the name of Annotto, Orlean, and Roucou.

The annotto commonly met with among us is moderately hard, of a brown colour on the outside, and a dull red within. It is difficultly acted upon by water, and tinges the liquor only of a pale brownish-yellow colour. In rectified spirit of wine it very readily dissolves, and communicates a high orange or yellowish-red. Hence it is used as an ingredient in varnishes, for giving more or less of an orange cast to the simple yellows.

Sulphuric ether is the best solvent of annotto. Potash and soda, either caustic or carbonated, dissolve annotto in great quantities; from which solutions it is thrown down by acids in small flocks. The alkaline solutions are of a deep red colour. Chlorine decolours the alcoholic solution of annotto; the liquor becoming speedily white and milky. If strong sulphuric acid be poured on annotto in powder, the red colour passes immediately to a very fine indigo blue; but this tint is not permanent: it changes to green, and finally to violet, in the course of 24 hours thereafter. This property of becoming blue belongs also to saffron. Nitric acid, slightly heated on annotto, sets it on fire; and a finely divided charcoal remains. Annotto is soluble both in essential oils, as oil of turpentine, and in fixed oils. *Boussingault Ann. de Chim. et de Phys.* xxviii. 440.

Beside its use in dyeing, it is employed for colouring cheese.

ANORTHITE. The primitive form of this mineral is a doubly oblique prism. The lustre of the cleavages is pearly, and that of the conchoidal fracture vitreous. The crystals of anorthite are clear and transparent, but small. Sp. grav. 2.763. Strong muriatic acid entirely decomposes it. It consists of silica, 44.49; alumina, 34.46; oxide of iron, 0.74; lime, 15.68; magnesia, 5.26.—*Rose.* The name anorthite, signifying without right angles, distinguishes it from felspar, two of whose cleavages are at right angles to each other.

ANTHOPHYLLITE. A massive mineral of a brownish colour; sometimes also crystallized, in thin flat six-sided prisms, streaked lengthwise. It has a false metallic lustre, glistening and pearly. In crystals, transparent. Massive, only translucent on the edges. It does not scratch glass, but fluate of lime. Specific gravity 3.2. Somewhat hard, but exceedingly brittle. Infusible alone before the blowpipe, but with borax it gives a grass-green transparent bead. It consists of 56 silica, 13.3 alumina, 14 magnesia, 3.33 lime, 6 oxide of iron, 3 oxide of manganese, 1.43 water, and 2.94 loss in 100. It is found at Konigsberg in Norway.

ANTHRACITE. Blind coal, Kilkenny coal, or glance coal. There are three varieties. 1. Massive, the conchoidal of Jameson. Its colour is iron-black, sometimes tarnished on the surface with a splendent metallic lustre. Fracture conchoidal, with a pseudo-metallic lustre. It is brittle and light. It yields no flame, and leaves whitish ashes. It is found in the newest floetz formations, at Meissner in Hesse, and Walsall in Staffordshire. 2. Slaty anthracite. Colour black, or brownish-black. Imperfect slaty in one direction, with a slight metallic lustre. Brittle. Specific gravity 1.4 to 1.8. Consumes without flame. It is composed of 72 carbon, 13 silica, 3.3 alumina, and 3.5 oxide of iron. It is found in both primitive and secondary rocks; at Calton Hill, Edinburgh; near Walsall, Staffordshire; in the southern parts of Brecknockshire, Carmarthenshire, and Pembrokeshire, whence it is called Welsh culm; near Cumnock and Kilmarnock, Ayrshire; and most abundantly at Kilkenny, Ireland. 3. Columnar anthracite. In small short prismatic concretions, of an iron black colour, with a tarnished metallic lustre. It is brittle, soft, and light. It yields no flame or smoke. It forms a thick bed near Sanquhar, in Dumfriesshire; at Saltcoats and New Cumnock, in Ayrshire. It occurs also at Meissner in Hesse.

ANTIMONY. The word antimony is used in commerce to denote a metallic ore, consisting of sulphur combined with the metal which is properly called antimony. Sometimes this sulphuret is termed crude antimony, to distinguish it from the pure metal, or regulus, as it was formerly called.

Antimony is of a dusky-white colour, very brittle, and of a plated or scaly texture. Its specific gravity, according to Brisson, is 6.7021, but Bergman makes it 6.86. Soon after ignition about 800° F. it melts, and by a continuance of the heat it becomes oxidized, and rises in white fumes, which may afterward be volatilized a second time, or fused into a hyacinthine glass, according to the management of the heat: the first were formerly called argentine flowers of regulus of antimony. In closed vessels the antimony rises totally without decomposition. This metallic substance is not subject to rust by exposure to air, though its surface becomes tarnished by that means.

There are certainly three, possibly four, distinct combinations of antimony and oxygen. 1. The protoxide of Berzelius is a blackish-grey powder, obtained from a mixture of powder of antimony and water, at the positive pole of a voltaic circuit. Heat enables this oxide to absorb oxygen rapidly, converting it into the tritoxide. According to Berzelius, it consists of 100 of metal, and 4.65 oxygen. It must be confessed, however, that the *data* for fixing these proportions are very doubtful. 2. The deutoxide may be obtained by digesting the metal in powder in muriatic acid, and pouring the solution into water of potash. Wash and dry the precipitate. It is a powder of a dirty white colour, which melts at a moderate red heat, and crystallizes as it cools. According to Berzelius, it consists of 84.3 metal + 15.7 oxygen. 3. The tritoxide, or antimonious acid, is the immediate product of the combustion of the metal, called of old, from its fine white colour, the argentine flowers of antimony. It may also be formed by digesting hot nitric acid on antimony. When fused with one-fourth of antimony, the whole becomes deutoxide. It forms the salts called antimonites with the different bases. According to Berzelius, the tritoxide consists of about 80 metal + 20 oxygen. 4. The peroxide, or antimonic acid, is formed when the metal in powder is ignited along with six times its weight of nitre in a silver crucible. The excess of potash and nitre being afterwards separated by hot water, the antimoniate of potash is then to be decomposed by muriatic acid, when the insoluble antimonic acid of a straw colour will be obtained. Nitro-muriatic acid likewise converts the metal into the peroxide. Though insoluble in water, it reddens the vegetable blues. It does not combine with acids. At a red heat oxygen is disengaged, and antimonious acid results. Berzelius infers its composition to be 76.34 metal + 23.66 oxygen. It is difficult to reconcile the above three portions of oxygen to one prime equivalent for antimony. The number 11 gives the best approximation to Berzelius's analyses. We shall then have the

			In 100 parts.
Deutoxide	11 metal	+ 2 oxy. or	84.6 + 15.4
Tritoxide	11	+ 3	78.6 + 21.4
Peroxide	11	+ 4	73.4 + 26.6

The first oxide is too imperfectly known to enter into the argument.

Mr. Rose of Berlin has ascertained the existence of three sulphurets of antimony. The native mineral dissolves entirely in muriatic acid, disengaging only sulphuretted hydrogen. It is also formed by passing sulphuretted hydrogen through solution of emetic tartar, or through butter of antimony dissolved in water and tartaric acid. It is in this case of an orange colour, but is a simple sulphuret, as is also, according to him, kermes mineral. The latter substance yielded him in 100 parts, 72.32 antimony + 27.68 sulphur. Now the native sulphuret by Berzelius contains 72.86 + 27.14; a near approximation. This seems to consist of 11 metal + 4 sulphur, or to be a bisulphuret. The next sulphuret has an orange colour, which resembles a good deal the golden sulphuret. It is formed by passing sulphuretted hydrogen through a solution of antimonious acid. The best way of procuring antimonious acid in solution, is to dissolve antimony in *aqua regia*, and to evaporate the solution to dryness. The antimonic acid thus formed is then ignited to convert it into antimonious acid; which is to be melted with caustic potash; and the fused mass is to be treated with hydrochloric acid and water, till a clear liquor be obtained. The sulphuret formed as above from this solution consists of 66.35 metal + 33.65 sulphur. The third sulphuret is the *sulphur antimonii auratum*, of which no analysis is given. *Ann. de Chim.* 1825.

Chlorine gas and antimony combine with combustion, and a bichloride results. This was formerly prepared by distilling a mixture of two parts of corrosive sublimate with one of antimony. The substance which came over, having a fatty consistence, was called butter of antimony. It is frequently crystallized in four-sided prisms. It is fusible and volatile at a moderate heat; and is resolved by water alone into the white oxide and muriatic acid. Being a bichloride, it is eminently corrosive, like the bichloride of mercury, from which it is formed. It consists of 45.7 chlorine + 54.3 antimony, according to Dr. John Davy's analysis, when the composition of the sulphuret is corrected by its recent exact analysis by Berzelius. But 11 antimony + 2 primes chlorine = 9.0, give the proportion per cent. of 44.1 + 55.5; a good coincidence, if we consider the circuitous process by which Dr. Davy's analysis was performed. Three parts of corrosive sublimate, and one of metallic antimony, are the equivalent proportions for making butter of antimony.

Iodine and antimony combine by the aid of heat into a solid iodide, of a dark red colour.

The phosphuret of this metal is obtained by fusing it with solid phosphoric acid. It is a white semicrystalline substance.

The sulphuret of antimony exists abundantly in nature. See ORES of ANTIMONY. It consists, according to Berzelius, of 100 antimony + 37.25 sulphur. The proportion given by the above equivalent ratio is 100 + 36.5. Other analyses have found 30, 33, and 35 to 100 of metal. Berzelius admits that there may be a slight error in his numbers.

The only important alloys of antimony are those of lead and tin; the former constitutes type metal, and contains about one-sixteenth of antimony; the latter alloy is employed for making the plates on which music is engraved.

The salts of antimony are of two different orders: in the first, the deutoxide acts the part of a salifiable base; in the second, the tritoxide and peroxide act the part of acids, neutralizing the alkaline and other bases, to constitute the antimonites and antimoniates.

The only distinct combination of the first order entitled to our attention, is the triple salt called tartrate of potash and antimony, or tartar emetic, and which, by M. Gay Lussac's new views, would be styled cream-tartrate of antimony. This constitutes a valuable and powerful medicine, and therefore the mode of preparing it should be correctly and clearly defined. As the dull white deutoxide of antimony is the true basis of this compound salt, and as that oxide readily passes by mismanagement into the tritoxide or antimonious acid, which is altogether unfit for the purpose, adequate pains should be taken to guard against so capital an error. In former editions of the British Pharmacopœias, the glass of antimony was prescribed as the basis of tartar emetic. More complex and precarious formulæ have been since introduced. The new edition of the Pharmacopée Française has given a recipe, which appears, with a slight change of proportions, to be unexceptionable. Take of the sulphuretted vitreous oxide of antimony, levigated and acidulous tartrate of potash, equal parts. Form a powder, which is to be put into an earthen or silver vessel, with a sufficient quantity of pure water. Boil the mixture for half an hour, adding boiling water from time to time; filter the hot liquor, and evaporate to dryness in a porcelain capsule; dissolve in boiling water the result of the evaporation, evaporate till the solution acquires the spec. grav. 1.161, and then let it repose, that crystals be obtained, which, by this process, will be pure. By another recipe, copied, with some alteration, from Mr. Phillips's prescription, into the appendix of the French Pharmacopœia, a subsulphate of antimony is formed first of all, by digesting two parts of sulphuret of antimony at a moderate heat, with three parts of oil of vitriol. This insoluble subsulphate being well washed, is then digested in a quantity of boiling water, with its own weight of cream of tartar, and evaporated to the density 1.161, after which it is filtered hot. On cooling, crystals of the triple tartrate are obtained. One might imagine, that there is a chance of obtaining by this process a mixture of sulphate of potash, and perhaps of a triple sulphate of antimony, along with the tartar emetic. Probably this does not happen, for it is said to yield crystals, very pure, very white, and without any mixture whatever.

Pure tartar emetic is in colourless and transparent tetrahedrons or octohedrons. It reddens litmus. Its taste is nauseous and caustic. Exposed to the air, it effloresces slowly. Boiling water dissolves half its weight, and cold water a fifteenth part. Sulphuric, nitric, and muriatic acids, when poured into a solution of this salt, precipitate its cream of tartar; and soda, potash, ammonia, or their carbonates, throw down its oxide of antimony. Barytes, strontites, and lime waters, occasion not only a precipitate of oxide of antimony, like the alkalis, but also insoluble tartrates of these earths. That produced by the alkaline hydrosulphurets is wholly formed of kermes;

while that caused by sulphuretted hydrogen contains both kermes and cream of tartar. The decoctions of several varieties of cinchona, and of several bitter and astringent plants, equally decompose tartar emetic; and the precipitate then always consists of the oxide of antimony, combined with the vegetable matter and cream of tartar. Physicians ought therefore to beware of such incompatible mixtures. When tartar emetic is exposed to a red heat, it first blackens, like all organic compounds, and afterwards leaves a residuum of metallic antimony and subcarbonate of potash. From this phenomenon, and the deep brownish-red precipitate, by hydrosulphurets, this antimonial combination may readily be recognized. The precipitate may further be dried on a filter, and ignited with black flux, when a globule of metallic antimony will be obtained. Infusion of galls is an active precipitant of tartar emetic.

This salt, in an undue dose, is capable of acting as a poison. The best antidotes are demulcent drinks, infusions of bark, tea, and sulphuretted hydrogen water, which instantly converts the energetic salt into a relatively mild sulphuret: anodynes are useful afterwards. The powder of tartar emetic, mixed with hog's lard, and applied to the skin of the human body, raises small vesications.

The composition of this salt, according to M. Thenard, is 35.4 acid, 39.6 oxide, 16.7 potash, and 8.2 water. The presence of the latter ingredient is obvious, from the undisputed phenomenon of efflorescence. By a recent analysis of Mr. Phillips, this salt is composed of;

1 atom bitartrate of potash	22.5	49.58
3 atoms protoxide of antimony	19.5	42.97
3 atoms water	3.375	7.45
		100.00

Dr. Thomson, however, assigns only 2 atoms of water from his researches published in his work on the first principles of Chemistry. Their atomic number for the oxide of antimony is one half of mine.

The deutoxide seems to have the property of combining with sulphur in various proportions. To this species of compound must be referred the liver of antimony, glass of antimony, and *crocus metallorum* of the ancient apothecaries. According to M. Soubeiran, glass of antimony contains—protoxide (deutoxide of Berz.) 91.5; silica, 4.5; peroxide of iron, 3.2; sulphuret of antimony, 1.9. Sulphuretted hydrogen forms, with the deutoxide of antimony, a compound which possessed at one time great celebrity in medicine, and of which a modification has lately been introduced into the art of calico printing. By dropping hydrosulphuret of potash, or of ammonia, into the cream tartrate, or into mild muriate of antimony, the hydrosulphuret of the metallic oxide precipitates of a beautiful deep orange colour. This is *kermes mineral.* Cluzel's process for obtaining a fine *kermes*, light, velvety, and of a deep purple-brown, is the following: one part of pulverized sulphuret of antimony, 22½ parts of crystallized subcarbonate of soda, and 200 parts of water, are to be boiled together in an iron pot. Filter the hot liquor into warm earthen pans, and allow them to cool very slowly. At the end of 24 hours the kermes is deposited. Throw it on a filter, wash it with water which had been boiled and then cooled out of contact with air. Dry the kermes at a temperature of 85°, and preserve in corked phials. Whatever may be the process employed, by boiling the liquor, after cooling and filtration, on new sulphuret of antimony, or upon that which was left in the former operation, this new liquid will deposit, on cooling, a new quantity of kermes. Besides the hydrosulphuretted oxide of antimony, there is formed a sulphuretted hydrosulphuret of potash or soda. Consequently, the alkali seizes a portion of the sulphur from the antimonial sulphuret, water is decomposed, and whilst a portion of its hydrogen unites to the alkaline sulphuret, its oxygen, and the other portion of its hydrogen, combine with the sulphuretted antimony. It seems, that the resulting kermes remains dissolved in the sulphuretted hydrosulphuret of potash or soda; but as it is less soluble in the cold than the hot, it is partially precipitated by refrigeration. If we pour into the supernatant liquid, after the kermes is deposited and removed, any acid, as the dilute nitric, sulphuric, or muriatic, we decompose the sulphuretted hydrosulphuret of potash or soda. The alkaline base being laid hold of, the sulphuretted hydrogen and sulphur to which they were united are set at liberty; the sulphur and kermes fall together, combine with it, and form an orange-coloured compound, called the golden sulphuret of antimony. It is a hydroguretted sulphuret of antimony. Hence, when it is digested with warm muriatic acid, a large residuum of sulphur is obtained, amounting sometimes to 12 per cent. Kermes is composed, by Thenard, of 20.3 sulphuretted hydrogen, 4.15 sulphur, 72.76 oxide of antimony, 2.79 water and loss; and the golden sulphuret consists of 17.87 sulphuretted hydrogen, 68.3 oxide of antimony, and 12 sulphur. Mr. Rose apparently proves that kermes is the same as the native sulphuret of antimony. See above.

By evaporating the supernatant kermes liquid, and cooling, crystals form, which have been lately employed by the calico printer to give a topical orange. These crystals are dissolved in water, and the solution being thickened with paste or gum, is applied to cloth in the usual way. After the cloth is dried, it is passed through a dilute acid, when the orange precipitate is deposited and fixed on the vegetable fibres.

An empirical antimonial medicine, called James's powder, has been much used in this country. The inventor called it his *fever powder*, and was so successful in his practice with it, that it obtained very great reputation, which it still in some measure retains. Probably the success of Dr. James was in great measure owing to his free use of the bark, which he always gave as largely as the stomach would bear, as soon as he had completely evacuated the primæ viæ by the use of his antimonial preparation, with which at first he used to combine some mercurial. His specification, lodged in Chancery, is as follows:—"Take antimony, calcine it with a continued protracted heat, in a flat, unglazed, earthen vessel, adding to it from time to time a sufficient quantity of any animal oil and salt, well dephlegmated; then boil it in melted nitre, for a considerable time, and separate the powder from the nitre by dissolving it in water." The real recipe has been studiously concealed, and a false one published in its stead. Different formulæ have been offered for imitating it. That of Dr. Pearson furnishes a mere mixture of an oxide of antimony, with phosphate of lime. The real powder of James, according to this chemist, consists of 57 oxide of antimony, with 43 phosphate of lime. It seems highly probable that superphosphate of lime would act on oxide of antimony in a way somewhat similar to cream of tartar, and produce a more chemical combination than what can be derived from a precarious ustulation, and calcination, of hartshorn shavings and sulphuret of antimony, in ordinary hands. The antimonial medicines are powerful deobstruents, promoting particularly the cuticular discharge. The union of this metallic oxide with sulphuretted hydrogen ought undoubtedly to favour its medicinal agency in chronic diseases of the skin. The kermes deserves more credit than it has hitherto received from British physicians.

The compounds formed by the antimonious and antimonic acids with the bases have not been applied to any use. Muriate of barytes may be employed as a test for tartar emetic. It will show, by a precipitate insoluble in nitric acid, if sulphate of potash be present. If the crystals be regularly formed, mere tartar need not be suspected.

For its ores, saline compounds, and the reduction of the metals, see Ores and Salt.

A fulminating antimonic powder has been prepared by M. Serullas in the following manner. Grind carefully together 100 parts of tartar emetic and 3 parts of lamp black, or ordinary charcoal powder. Crucibles capable of holding about 3 ounces of water, to be only three-fourths filled, are to be ground smooth on their edges, and rubbed inside with powdered charcoal, so as to dust lightly their surface, and prevent the subsequent adherence of the carbonaceous cone which remains after the calcination. The above mixture being introduced into the crucible, is to be covered with a layer of powdered charcoal; and the joinings of the cover must be luted. After exposure for 3 hours to a good heat in a reverberatory furnace, the crucible, must be removed, and left to cool for 6 or 7 hours. This interval of time is necessary to allow the air, which always penetrates a little way into the crucibles, to burn the exterior coat of the fulminating mass; otherwise, if it be taken out too recently, there is always an explosion. We must then hastily enclose it, without breaking, into a glass with a wide opening. After some time, it spontaneously breaks down into fragments of different sizes, retaining all its properties for years. When the calcination has been conducted as above, the product is excessively fulminating, so that, without the least compression, it gives rise to a violent detonation on contact with water. 100 parts of antimony, 75 of carburetted cream of tartar, and 12 of lamp black, triturated together, form also an excellent mixture. A piece of the size of a pea of this fulminating compound introduced into a mass of gunpowder explodes it when thrown into water. It is to the presence of potassium that the above explosive property is due. 60 parts of carburetted cream of tartar, 120 of bismuth, and 1 of nitre, treated as above, yield an alloy very rich in potassium, of which the smallest portion cut with scissars sparkles. When bruised it melts and burns.—*Ann. de Chim. Oct.* 1822.

ANTS. See Acid (Formic).

APATITE. Phosphate of lime. This mineral occurs both massive and crystallized. The crystals are six-sided prisms, low, and sometimes passing into the six-sided table. Lateral edges, frequently truncated, and the faces smooth. Lustre splendent. Translucent, rarely transparent. Scratched by fluor spar. Brittle. Colours, white, wine-yellow, green, and red. Sp. grav. 3.1. Phosphoresces on coals. Electric by heat and friction. Consists of 53.75 lime + 46.25 phosphoric acid, by Klaproth's analysis of the variety called asparagus stone. It occurs in primitive rocks; in the tin veins of the granite of St. Michael's Mount, Cornwall; near Chudleigh in Devonshire; at Nantes in France; in St. Gothard, and in Spain; and with molybdena in granite, near Colbeck, Cumberland. *Phosphorite* is massive, forming great beds in the province of Estremadura. Yellowish-white colour. Dull or glimmering lustre. Semi-hard. Fracture, imperfect curve foliated. Brittle. Sp. grav. 2.8. Phosphorescent with heat. Its composition by Pelletier is 59 lime, 34 phosphoric acid, 1 carbonic acid, 2.5 fluoric acid, 2 silica, 1 oxide of iron, and 0.5 muriatic acid.

APHLOGISTIC LAMP. One which burns without flame. See Combustion.

APHANITE. This is the name given by Haüy to a rock apparently homogeneous, but really compound, in which amphibole is the predominant principle. It is a green-stone, the distinction of whose parts is indiscernible. Aphanite is included among the rocks, which the older mineralogists called *cornéennes*, or *lapis corneus trapezius*.

APHRITE. Earth foam; Schaumerde. This carbonate of lime occurs usually in a friable state; but sometimes solid. Colour, almost silver white. Massive, or in fine particles. Shining lustre, between semi-metallic and pearly. Fracture, curve foliated. Opaque; soils a little. Very soft, and easily cut. Feels fine and light. It is usually found in calcareous veins, at Gera in Misnia, and Eisleben in Thuringia. It consists, by Bucholz, of 51.5 lime, 39 acid, 1 water, 5.7 silica, 3.3 oxide of iron.

APHRIZITE. A variety of black tourmaline.

APLOME. This is commonly considered to be a variety of the garnet; but the difference between these minerals is this: the planes of the *aplome* dodecahedrons are striated parallel with their smaller diagonal, which, according to Haüy, indicates the primitive form to be a cube, and not a dodecahedron. Its colour is deep orange-brown. It is opaque, and harder than quartz. Sp. grav. is much less than garnet, viz. 3.44. It consists, by Laugier's analysis, of 40 silica, 20 alumina, 14.5 lime, 14 oxide of iron, 2 oxide of manganese, 2 silica and iron. It is fusible into a black glass, while garnet fuses into a black enamel. It is found on the river Lena in Siberia, and also in New Holland.

APOPHYLLITE. Ichthyophthalmite. Fish-eyestone. It is found both massive and crystallized. It occurs in square prisms, whose solid angles are sometimes replaced by triangular planes, or the prisms are terminated by pyramids consisting of 4 rhomboidal planes. Structure lamellar; cross fracture, fine-grained, uneven. External lustre, splendent, and peculiar; internal, glistening and pearly. Semi-transparent, or translucent. Moderately hard, and easily broken. Sp. grav. 2.49. It exfoliates, then froths, and melts into an opaque bead before the blowpipe. It consists of 51 silica, 28 lime, 4 potash, 17 water. *Vauquelin.* It is found in the iron mine of Utoe in Sweden, at the copper mine of Fahlun, at Arendahl, Faroe, the Tyrol; and Dr. MacCulloch met with a solitary crystal in Dunvegan, in the Isle of Skye.

APPARATUS. See LABORATORY.

APPLES. See ACID (MALIC).

APYROUS. Bodies which sustain the action of a strong heat for a considerable time, without change of figure or other properties, have been called apyrous; but the word is seldom used in the art of chemistry. It is synonymous with *refractory*.

AQUAFORTIS. This name is given to a weak and impure nitric acid, commonly used in the arts. It is distinguished by the terms *double* and *single*, the single being only half the strength of the other. The artists who use these acids call the more concentrated acid, which is much stronger even than the double aquafortis, *spirit of nitre*. See ACID (NITRIC).

AQUA MARINE. See BERYL.

AQUA REGIA, or REGIS. This acid, being compounded of a mixture of the nitric and muriatic acids, is now termed by chemists nitro-muriatic acid.

AQUA VITÆ. Ardent spirit of the first distillation has been distinguished in commerce by this name. The distillers of malt and melasses spirits call it low wines.

AQUILA ALBA. One of the names given to the combination of muriatic acid and mercury in that state, which is commonly known by the denomination of *mercurius dulcis*, *calomel*, *or mild muriate of mercury*.

ARABIC (GUM). This is reckoned the purest of gums, and does not greatly differ from gum Senegal, vulgarly called gum seneca, which is supposed to be the strongest, and is on this account, as well as its greater plenty and cheapness, mostly used by calico printers and other manufacturers. The gums of the plum and the cherry-tree have nearly the same qualities as gum arabic. All these substances facilitate the mixture of oils with water. By my analysis, gum arabic is composed in 100 parts of 35.13 carbon; 6.08 hydrogen; 55.79 oxygen; and possibly 3 of azote.

ARABLE LANDS. It is a problem in chemistry, and by no means one of the least importance to society, to determine what are the requisites which distinguish fruitful lands from such as are less productive. See SOILS, and ANALYSIS of SOILS.

ARBOR DIANÆ. See SILVER.

ARCHIL, ARCHILLA, ROCELLA, ORSEILLE. A whitish lichen, growing upon rocks in the Canary and Cape Verd Islands, which yields a rich purple tincture, fugitive indeed, but extremely beautiful. This weed is imported to us as it is gathered: those who prepare it for the use of the dyer, grind it betwixt stones, so as thoroughly to bruise, but not to reduce it into powder, and then moisten it occasionally with a strong spirit of urine, or urine itself mixed with quicklime: in a few days it acquires a purplish-red, and at length a blue colour; in the first state it is called archil, in the latter lacmus or litmus.

The dyers rarely employ this drug by itself, on account of its dearness, and the perishableness of its beauty. The chief use they make of it is for giving a bloom to other colours, as pinks, &c. This is effected by passing the dyed cloth or silk through hot water slightly impregnated with the archil. The bloom thus communicated soon decays upon exposure to the air. Mr. Hellot informs us, that by the addition of a little solution of tin, this drug gives a durable dye; that its colour is at the same time changed toward a scarlet; and that it is the more permanent, in proportion as it recedes the more from its natural colour.

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* Non manifestus.

Prepared archil very readily gives out its colour to water, to volatile spirits, and to alcohol; it is the substance principally made use of for colouring the spirits of thermometers. As exposure to the air destroys its colour upon cloth, the exclusion of the air produces a like effect in those hermetically sealed tubes, the spirits of large thermometers becoming in a few years colourless. The Abbé Nollet observes, (in the French Memoirs for the year 1742), that the colourless spirit, upon breaking the tube, soon resumes its colour, and this for a number of times successively; that a watery tincture of archil, included in the tubes of thermometers, lost its colour in three days; and that in an open deep vessel it became colourless at the bottom, while the upper part retained its colour.

A solution of archil in water, applied on cold marble, stains it of a beautiful violet or purplish-blue colour, far more durable than the colour which it communicates to other bodies. M. du Fay says, he has seen pieces of marble stained with it, which in two years had suffered no sensible change. It sinks deep into the marble, sometimes above an inch, and at the same time spreads upon the surface, unless the edges be bounded by wax or some similar substance. It seems to make the marble somewhat more brittle.

There is a considerable consumption of an article of this kind manufactured in Glasgow by Mr. Mackintosh. It is much esteemed, and sold by the name of cudbear. We have seen beautiful specimens of silk thus dyed, the colours of which were said to be very permanent, of various shades, from pink and crimson to a bright mazarine blue.

Litmus is likewise used in chemistry as a test, either staining paper with it, or by infusing it in water, when it is very commonly, but with great impropriety, called *tincture of turnsole*. The persons by whom this article was prepared formerly, gave it the name of turnsole, pretending that it was extracted from the turnsole, heliotropium tricoccum, in order to keep its true source a secret. The tincture should not be too strong, otherwise it will have a violet tinge, which, however, may be removed by dilution. The light of the sun turns it red even in close vessels. It may be made with spirit instead of water. This tincture, or paper stained with it, is presently turned red by acids: and if it be first reddened by a small quantity of vinegar, or some weak acid, its blue colour will be restored by an alkali.

ARCTIZITE. See WERNERITE.

ARDENT SPIRIT. See ALCOHOL.

ARENDATE. See PISTACITE.

AREOMETER. See HYDROMETER.

ARFWEDSONITE. A ferruginous variety of hornblende. Colour black; cleavage planes much more brilliant than those of hornblende, which scratches it. Sp. gravity 3.44. It sometimes accompanies the sodalite from Greenland.

ARGAL. Crude tartar, in the state in which it is taken from the inside of wine vessels, is known in the shops by this name.

ARGENTATE OF AMMONIA. Fulminating silver.

ARGENTINE FLOWERS OF ANTIMONY. The deutoxide of the English chemists, or the antimonious acid.

ARGILLACEOUS EARTH. See ALUMINA.

ARGILLITE. See CLAY-SLATE.

AROMATICS. Plants which possess a fragrant smell united with pungency, and at the same time are warm to the taste, are called aromatics. Their peculiar flavour appears to reside in their essential oil, and rises in distillation either with water or spirit.

ARRACK. A spirituous liquor imported from the East Indies. It is chiefly manufactured at Batavia, and at Goa, upon the Malabar coast.

ARRAGONITE. This mineral occurs massive, in fibres of a silky lustre, and in the form of fibrous branches, diverging from a centre, *Flos-ferri*. It is frequently crystallized in what appear at first sight to be regular six-sided prisms. On close inspection a longitudinal crack will be observed down each lateral face. It occurs also in elongated octohëdrons. Lustre glassy, fracture foliated and fibrous. Colours greenish and pearl-grey; often violet and green in the middle; and arranged in the direction of the fibres, so that the longitudinal fibres are green, the transverse violet-blue. Double cleavage—translucent—refracts doubly—scratches calcareous spar, and sometimes even glass—brittle—sp. grav. 2.90. It consists of carbonate of lime, with occasionally a little carbonate of strontites. It is found in Arragon, in Spain; at Leogany, in Salzburg; at Marienberg, in Saxony; and Sterzing in the Tyrol; in the cavities of basalt near Glasgow. The finest specimens of the Flos-ferri ramifications come from the mines of Eisenerz, in Stiria; beautiful specimens have been also found in the Dufton lead mines in England, in the workings of an old coal mine, called Lufton-hill pit, near Durham. It also occurs in the trap rocks of Scotland.

ARROW ROOT. This fecula is obtained from the roots of the Maranta Arundinacea, a plant cultivated in the West Indies. The roots are washed, and beat to a pulp in large wooden mortars, which is afterwards separated from fibrous matter by agitation with water in large tubs. The milky liquor is passed through a sieve, and allowed to subside. When thoroughly washed and dried, it constitutes this nutritive species of starch; very analogous to well purified potato starch.

ARSENIC, in the metallic state, is of a bluish-white colour, subject to tarnish, and grow first yellowish, then black, by exposure to air. It is brittle, and when broken exhibits a laminated texture. Its specific gravity is 5.763. In close vessels it sublimes entire at 356° F. but burns with a small flame if oxygen be present.

The arsenic met with in commerce has the form of a white oxide. It is brought chiefly from the cobalt works in Saxony, where zaffre is made. Cobalt ores contain much arsenic, which is driven off by long torrefaction. The ore is thrown into a furnace, resembling a baker's oven, with a flue, or horizontal chimney, nearly two hundred yards long, into which the fumes pass, and are condensed into a greyish or blackish powder. This is refined by a second sublimation in close vessels, with a little potash, to detain the impurities. As the heat is considerable, it melts the sublimed flowers into those crystalline masses which are met with in commerce. See ACID (ARSENIOUS).

The metal may be obtained from this, either by quickly fusing it together with twice its weight of soft soap and an equal quantity of alkali, and pouring it out, when fused, into a hot iron cone; or by mixing it in powder with oil, and exposing it in a matrass to a sand heat. This process is too offensive to be performed except in the open air, or where a current of air carries off the fumes. The decomposed oil first rises; and the arsenic is afterwards sublimed in the form of a flaky metallic substance. It may likewise be obtained by mixing two parts of the arsenious acid with one of black flux; putting the mixture into a crucible, with another inverted over it, and luted to it with clay and sand; and applying a red heat to the lower crucible. The metal will be reduced, and line the inside of the upper crucible.

It is among the most combustible of the metals, burns with a blue flame, and garlic smell, and sublimes in the state of arsenious acid.

Concentrated sulphuric acid does not attack arsenic when cold; but if it be boiled upon this metal, sulphurous acid gas is emitted, a small quantity of sulphur sublimes, and the arsenic is reduced to an oxide.

Nitrous acid readily attacks arsenic, and converts it into arsenious acid, or, if much be employed, into arsenic acid.

Boiling muriatic acid dissolves arsenic, but affects it very little when cold. This solution affords precipitates upon the addition of alkalis. The addition of a little nitric acid expedites the solution; and this solution, first heated and condensed in a close vessel, is wholly sublimed into a thick liquid, formerly termed *butter of arsenic.* Thrown in powder into chlorine gas it burns with a bright white flame, and is converted into a chloride.

None of the earths or alkalis act upon it, unless it be boiled a long while in fine powder, in a large proportion of alkaline solution.

Nitrates detonate with arsenic, convert it into arsenic acid, and this, combining with the base of the nitrate, forms an arseniate, that remains at the bottom of the vessel.

Muriates have no action upon it; but if three parts of chlorate of potash be mixed with one part of arsenic in fine powder, which must be done with great precaution, and a very light hand, a very small quantity of this mixture, placed on an anvil, and struck with a hammer, will explode with flame and a considerable report; if touched with fire, it will burn with considerable rapidity; and if thrown into concentrated sulphuric acid, at the instant of contact a flame rises into the air like a flash of lightning, which is so bright as to dazzle the eye.

Arsenic readily combines with sulphur by fusion and sublimation, and forms a yellow compound called *orpiment*, or a red called *realgar*. The nature of these, and their difference, are not accurately known; but Fourcroy considers the first as a combination of sulphur with the oxide, and the second as a combination of sulphur with the metal itself, as he found the red sulphuret converted into the yellow by the action of acids.

Arsenic is soluble in fat oils in a boiling heat; the solution is black, and has the consistence of an ointment when cold. Most metals unite with arsenic; which exists in the metallic state in such alloys as possess the metallic brilliancy.

Iodine and arsenic unite, forming an iodide, of a dark purple-red colour, possessing the properties of an acid. It is soluble in water, and its solution forms a soluble compound with potash. Arsenic combines with hydrogen into a very noxious compound, called arsenuretted hydrogen gas. To prepare it, fuse in a covered crucible 3 parts of granulated tin, and 1 of metallic arsenic in powder; and submit this alloy, broken in pieces, to the action of muriatic acid in a glass retort. On applying a moderate heat, the arsenuretted hydrogen comes over, and may be received in a mercurial or water pneumatic trough. Protomuriate of tin remains in the retort. When 1 of arsenic is used for 15 of tin, the former metal is entirely carried of in the evolved hydrogen. 100 parts of this gas contain 140 of hydrogen, as is proved by heating it with tin. Its specific gravity, according to Sir H. Davy, is 0.5552; according to Trommsdorf, 0.5293. Stromeyer states, that by a cold of — 22° it condenses into a liquid. Exploded with twice its bulk of oxygen, water and oxide of arsenic are formed. When arsenuretted hydrogen issuing from a tube is set on fire, it deposits a hydruret of arsenic. Sulphur, potassium, sodium, and tin, decompose this gas, combine with its metal; and in the case of sulphur, sulphuretted hydrogen results. By subtracting from the specific gravity of the arsenuretted gas that of hydrogen gas $\times \frac{140}{100}$, we have the proportion of arsenic present; $0.55520 - 0.09716 = 0.45804 =$ the arsenic in 100 measures of arsenuretted hydrogen; which gives the proportion by weight of about 5 arsenic to 1 hydrogen; but Stromeyer's analysis by nitric acid gives about 50 arsenic to 1 hydrogen, which is probably much nearer the true composition. A prime equivalent of hydrogen is to one of arsenic as 1 to 76; and 2 consequently as 1 to 38. Gehlen fell a victim to his researches on this gas; and therefore the new experiments requisite to elucidate its constitution must be conducted with circumspection. If chlorine be added to a mixture of arsenuretted and sulphuretted hydrogen, the bulk diminishes, and yellow-coloured flakes are deposited. Concentrated nitric acid occasions an explosion in this gas, preceded by nitrous fumes: but if the acid be diluted, a silent decomposition of the gas is effected. The density of the hydrogen in this compound gas is 0.09716. Therefore, by Stromeyer's analysis, we have this proportion to calculate the specific gravity of the gas, $2.19 : 0.09716 :: (2.19 + 106) : 4.827$; a quantity nearly 9 times greater than what experiment has given.

This gas extinguishes flame, and instantly destroys animal life. Water has no effect upon it. From the experiments of Sir H. Davy and MM. Gay Lussac and Thenard, there appears to be a solid compound of hydrogen and arsenic, or a hydruret. It is formed by acting with the negative pole of a voltaic battery on arsenic plunged in water. It is reddish-brown, without lustre, taste, or smell. It is not decomposed at a heat approaching to cherry-red; but at this temperature it absorbs oxygen; while water and arsenious acid are formed, with the evolution of heat and light. The proportion of the two constituents is not known.

Arsenic is used in a variety of arts. It enters into metallic combinations, wherein a white colour is required. Glass manufacturers use it; but its effect in the composition of glass does not seem to be clearly explained. Orpiment and realgar are used as pigments. See ACIDS (ARSENIC, and ARSENIOUS,) and SALT.

ASAFŒTIDA is obtained from a large umbelliferous plant growing in Persia. The root resembles a large parsnep, externally of a black colour: on cutting it transversely, the asafœtida exudes in form of a white thick juice, like cream; which, from exposure to the air, becomes yellower and yellower, and at last of a dark brown colour. It is very apt to run into putrefaction; and hence those who collect it carefully defend it from the sun. The fresh juice has an excessively strong smell, which grows weaker and weaker upon keeping; a single dram of the fresh fluid juice smells more than a hundred pounds of the dry asafœtida brought to us. The Persians are commonly obliged to hire ships on purpose for its carriage, as scarcely any one will receive it along with other commodities, its stench infecting every thing that comes near it.

The common asafœtida of the shops is of a yellowish or brownish colour, unctuous and tough, of an acrid or biting taste, and a strong disagreeable smell, resembling that of garlic. From four ounces Neumann obtained, by rectified spirit, two ounces six drams and a half of resinous extract; and afterward, by water, three drams and half a scruple of gummy extract, about six drams and a scruple of earthy matter remaining undissolved. On applying water at first, he gained, from four ounces, one ounce three scruples and a half of gummy extract.

Asafœtida is administered in nervous and hysteric affections, as a deobstruent, and sometimes as an anthelmintic. A tincture of it is kept in the shops, and it enters into the composition of the compound galbanum pill of the London college, the gum pill of former dispensatories.

ASBESTOS or ASBESTUS. A mineral of which there are five varieties, all more or less flexible and fibrous.

1. *Amianthus* occurs in very long, fine, flexible, elastic fibres, of a white, greenish, or reddish colour. It is somewhat unctuous to the touch, has a silky or pearly lustre, and is slightly translucent. Sectile; tough; sp. gr. from 1 to 2.3. Melts with difficulty before the blowpipe, into a white enamel. It is usually found in serpentine; in the Tarentaise in Savoy; in long and beautiful fibres, in Corsica; near Barèges, in the Pyrenees; in Dauphiny and St. Gothard; at St. Keverne, Cornwall; at Portsoy, Scotland; in mica slate at Glenelg, Inverness-shire, and near Durham. It consists of 59 silex, 25 magnesia, 9.5 lime, 3 alumina, and 2.25 oxide of iron.

The ancients manufactured cloth out of the fibres of asbestos, for the purpose, it is said, of wrapping up the bodies of the dead, when exposed on the funeral pile. Several moderns have likewise succeeded in making this cloth; the chief artifice of which seems to consist in the admixture of flax and a liberal use of oil; both which substances are afterwards consumed by exposing the cloth for a certain time to a red heat. Although the cloth of asbestos, when soiled, is restored to its primitive whiteness by heating in the fire; it is found, nevertheless, by several authentic experiments, that its weight diminishes by such treatment. The fibres of asbestos, exposed to the violent heat of the blowpipe, exhibit slight indications of fusion; though the parts, instead of running together, moulder away, and part fall down, while the rest seem to disappear before the current of air. Ignition impairs the flexibility of asbestos in a slight degree.

2. *Common Asbestus* occurs in masses of fibres of a dull greenish colour, and of a somewhat pearly lustre. Fragments splintery. It is scarcely flexible, and greatly denser than amianthus. It is slightly unctuous to the touch. Sp. grav. 2.7. Fuses with difficulty into a greyish-black scoria. It is composed of 63.9 silica, 16 magnesia, 12.8 lime, 6 oxide of iron, and 1.1 alumina. It is more abundant than amianthus, and is found usually in serpentine, as at Portsoy, the Isle of Anglesea, and the Lizard in Cornwall. It was found in the limestone of Glentilt, by Dr. M'Culloch, in a pasty state, but it soon hardened by exposure to air.

3. *Mountain Leather* consists not of parallel fibres like the preceding, but interwoven and interlaced so as to become tough. When in very thin pieces it is called *mountain paper*. Its colour is yellowish-white, and its touch meagre. It is found at Wanlockhead, in Lanarkshire. Its specific gravity is uncertain.

4. *Mountain Cork*, or *Elastic Asbestus*, is, like the preceding, of an interlaced fibrous texture; is opaque, has a meagre feel and appearance, not unlike common cork, and like it too, is somewhat elastic. It swims on water. Its colours are, white, grey, and yellowish-brown. Receives an impression from the nail; very tough; cracks when handled, and melts with difficulty before the blowpipe. Sp. grav. from 0.68 to 0.99. It is composed of silica 62, carbonate of lime 12, carbonate of magnesia 23, alumina 2.8, oxide of iron 3.

5. *Mountain Wood.* Ligniform asbestus. Is usually massive, of a brown colour, and having the aspect of wood. Internal lustre glimmering. Soft, sectile, and tough; opaque; feels meagre; fusible into a black slag. Sp. grav. 2.0. It is found in the Tyrol; Dauphiny; and in Scotland, at Glentilt, Portsoy, and Kildrumie.

ASHES. The fixed residue of combustible substances, which remains after they have been burned, is called ashes. In chemistry it is most commonly used to denote the residue of vegetable combustion.

ASPARAGIN. White transparent crystals, of a peculiar vegetable principle, which spontaneously form in asparagus juice which has been evaporated to the consistence of syrup. They are in the form of rhomboidal prisms, hard and brittle, having a cool and slightly nauseous taste. They dissolve in hot water, but sparingly in cold water, and not at all in alcohol. On being heated they swell, and emit penetrating vapours, which affect the eyes and nose like wood-smoke. Their solution does not change vegetable blues; nor is it affected by hydro-sulphuret of potash, oxalate of ammonia, acetate of lead, or infusion of galls. Lime disengages ammonia from it; though none is evolved by triturating it with potash. The asparagus juice should be first heated to coagulate the albumen, then filtered and left to spontaneous evaporation for 15 or 20 days. Along with the asparagin crystals, others in needles of little consistency appear, analogous to *mannite*, from which the first can be easily picked out.—*Vauquelin and Robiquet. Annales de Chimie, vol. 55. and Nicholson's Journal*, 15.

ASPHALTUM. This substance, likewise called Bitumen Judaicum, or Jews' Pitch, is a smooth, hard, brittle, black or brown substance, which breaks with a polish, melts easily when heated, and when pure burns without leaving any ashes. It is found in a soft or liquid state on the surface of the Dead Sea*, but by age grows dry and hard. The same kind of bitumen is likewise found in the earth in other parts of the world; in China; America, particularly in the island of Trinidad; and some parts of Europe, as the Carpathian hills, France, Neufchatel, &c. Its specific gravity, according to Boyle, is 1.400, to Kirwan, from 1.07 to 1.65. A specimen from Albania, of the specific gravity of 1.205, examined by M. Klaproth, was found to be soluble only in oils and in ether. Five parts of rectified oil of petroleum dissolved one of the asphaltum, without heat, in 24 hours. Analyzed in the dry way, 100 grains afforded 32 of bituminous oil, 6 of water faintly ammoniacal, 30 of charcoal, 7½ of silex, 7½ of alumina, ¾ of lime, 1¼ oxide of iron, ½ oxide of manganese, and 36 cubic inches of hydrogen gas.

According to Neumann, the asphaltum of the shops is a very different compound from the native bitumen; and varies, of course, in its properties, according to the nature of the ingredients made us of in forming it. On this account, and probably from other reasons, the use of asphaltum, as an article of the materia medica, is almost totally laid aside.

The Egyptians used asphaltum in embalming, under the name of mumia mineralis, for which it is well adapted. It was used for mortar at Babylon.

ASSAY, *or* ESSAY. This operation consists in determining the quantity of valuable or precious metal contained in any mineral or metallic mixture, by analyzing a small part thereof. The practical difference between the analysis and the assay of an ore consists in this: the analysis, if properly made, determines the nature and quantities of all the parts of the compound; whereas, the object of the assay consists in ascertaining how much of the particular metal in question may be contained in a certain determinate quantity of the material under examination. Thus, in the assay of gold or silver, the baser metals are considered as of no value or consequence; and the problem to be resolved is simply, how much of each is contained in the ingot or piece of metal intended to be assayed. The examination of metallic ores may be seen under their respective titles; the present article will therefore consist of an account of the assaying of gold and silver.

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* In the Mem. of the Academy of Sciences of Paris for 1778, there is an analysis of the water of this sea by Messrs. Macquer, Lavoisier, and Sage; by which it appears to contain 22 per cent. of muriate of magnesia, 16½ of muriate of lime, and 6½ of muriate of soda. Its specific gravity is 1·25. It is limpid, and without smell.

To obtain gold or silver in a state of purity, or to ascertain the quantity of alloy it may contain, it is exposed to a strong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows: The precious metal is put, together with a due proportion of lead, into a shallow crucible, made of burned bones, called a cupel; and the fusion of the metals is effected by exposing them to a considerable heat in a muffle, or small earthen oven, fixed in the midst of a furnace. The lead continually vitrifies, or becomes converted into a glassy calx, which dissolves all the imperfect metals. This fluid glass, with its contents, soaks into the cupel, and leaves the precious metals in a state of purity. During the cupellation, the scoriæ running down on all sides of the metallic mass produce an appearance called circulation: by which the operator judges whether the process be going on well. When the metal is nearly pure, certain prismatic colours flash suddenly across the surface of the globule, which soon afterward appears very brilliant and clean: this is called the brightening, and shows that the separation is ended.

After gold has passed the cupel, it may still contain either of the other perfect metals, platina or silver. The former is seldom suspected; the latter is separated by the operations called quartation and parting. Quartation consists in adding three parts of silver to the supposed gold, and fusing them together; by which means the gold becomes at most one-fourth of the mass only. The intention of this is to separate the particles of gold from each other, so that they may not cover and defend the silver from the action of the nitric acid, which is to be used in the process of parting. Parting consists in exposing the mass, previously hammered or rolled out thin, to the action of seven or eight times its weight of boiling nitric acid of a due strength. The first portion of nitric acid being poured off, about half the quantity, of a somewhat greater strength, is to be poured on the remaining gold; and if it be supposed that this has not dissolved all the silver, it may even be repeated a second time. For the first operation an acid of the specific gravity of 1.280 may be used, diluted with an equal quantity of water; for the second, an acid about 1.26 may be taken undiluted. If the acid be not too concentrated, it dissolves the silver, and leaves the gold in a porous mass, of the original form; but, if too strong, the gold is in a powdery form, which may be washed and dried. The weight of the original metal before cupellation, and in all the subsequent stages, serves to ascertain the degree of fineness of the ingot, or ore, of which it is a part.

In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh twenty-four carats of twelve grains each, either real, or merely proportional, like the assayer's weights; and the pure gold is called fine. Thus, if gold be said to be 23 carats fine, it is to be understood, that in a mass weighing 24 carats, the quantity of pure gold amounts to 23 carats.

In such small works as cannot be assayed by scraping off a part, and cupelling it, the assayers endeavour to ascertain its quality or fineness by the touch. This is a method of comparing the colour, and other properties, of a minute portion of the metal, with those of small bars, the composition of which is known. These bars are called touchneedles; and they are rubbed upon the black basaltes, which, for this reason, is called the touchstone. Black flint or pottery will serve the same purpose. Sets of gold needles may consist of—pure gold; pure gold 23½ carats, with half a carat of silver; 23 carats of gold, with one carat of silver; 22½ carats of gold, with 1½ carats of silver; and so on, till the silver amounts to four carats; after which the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition consisting either of equal parts silver and copper, or such proportions as the occasions of business require. The examination by the touch may be advantageously employed previous to quartation, to indicate the quantity of silver necessary to be added.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not much used in England. They afford, however, a degree of information which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touchstone by the metal under examination, with that produced by his needle; but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes perfectly alike in colour are made upon the stone, he may then wet them with aquafortis, which will affect them very differently, if they be not similar compositions; or the stone itself may be made red-hot by the fire, or by the blowpipe, if thin black pottery be used; in which case the phenomena of oxidation will differ according to the nature and quantity of the alloy.

The French government has from time to time caused various experimental inquiries to be made respecting the art of assaying gold, which have thrown much light on this subject, and greatly tend to produce uniformity in the results of the operation. The latest report on this subject may be seen in the Annales de Chimie, vol. vi. p. 64.; which may be consulted for a full account of the experiments and history of former proceedings. The general result is as follows, nearly in the words of the authors:—

Six principal circumstances appear to affect the operation of parting: namely, the quantity of acid used in parting, or in the first boiling; the concentration of this acid; the time employed in its application; the quantity of acid made use of in the reprise, or second operation; its concentration; and the time during which it is applied. From the experiments it has been shown, that each of these unfavourable circumstances might easily occasion a loss of from the half of a thirty-second part of a carat, or two thirty-second parts. The writers explain their technical language by observing, that, the whole mass consisting of twenty-four carats, this thirty-second part denotes 1-768th part of the mass. It may easily be conceived, therefore, that if the whole six circumstances were to exist, and be productive of errors falling the same way, the loss would be very considerable.

It is therefore indispensably necessary, that one uniform process should be followed in the assays of gold; and it is a matter of astonishment, that such an accurate process should not have been prescribed by government for assayers in an operation of such great commercial importance, instead of every one being left to follow his own judgment. The process recommended in the report before us is as follows:—

Twelve grains of the gold intended to be assayed must be mixed with thirty grains of fine silver, and cupelled with 108 grains* of lead. The cupellation must be carefully attended to, and all the imperfect buttons rejected. When the cupellation is ended, the button must be reduced by lamination into a plate of 1½ inch, or rather more, in length, and four or five lines in breadth. This must be rolled up upon a quill, and placed in a matrass capable of holding about three ounces of liquid, when filled up to its narrow part. Two ounces and a half of very pure aquafortis, of the strength of 20 degrees of Baume's areometer, must then be poured upon it; and the matrass being placed upon hot ashes, or sand, the acid must be kept gently boiling for a quarter of an hour; the acid must then be cautiously decanted, and an additional quantity of 1½ ounce must be poured on the metal, and slightly boiled for twelve minutes. This being likewise carefully decanted, the small spiral piece of metal must be washed with filtered river water, or distilled water, by filling the matrass with this fluid. The vessel is then to be reversed, by applying the extremity of its neck against the bottom of a crucible of fine earth, the internal surface of which is very smooth. The annealing must then be made, after having separated the portion of water which had fallen into the crucible; and, lastly, the annealed gold must be weighed. For the certainty of this operation, two assays must be made in the same manner, together with a third assay upon gold of twenty-four carats, or upon gold the fineness of which is perfectly and generally known.

No conclusion must be drawn from this assay, unless the latter gold should prove to be of the fineness of twenty-four carats exactly, or of its known degree of fineness; for, if there be either loss or surplus, it may be inferred, that the other two assays, having undergone the same operation, must be subject to the same error. The operation being made according to this process, by several assayers, in circumstances of importance, such as those which relate to large fabrications, the fineness of the gold must not be depended on, nor considered as accurately known, unless all the assayers have obtained an uniform result, without communication with each other. The authors observe, however, that this identity must be considered as existing to the accuracy of half of the thirty-second part of a carat. For, notwithstanding every possible precaution or uniformity, it very seldom happens that an absolute agreement is obtained between the different assays of one and the same ingot, because the ingot itself may differ in its fineness in different parts of its mass.

The assaying of silver does not differ from that of gold, excepting that the parting operation is not necessary. A certain small portion of the silver is absorbed by the cupel, and the more when a larger quantity of lead is used, unless the quantity of lead be excessive; in which case most of it will be scorified before it begins to act upon the silver. Messrs. Hellot, Tillet, and Macquer, from their experiments made by order of the French government, have ascertained, that four parts of lead are requisite for silver of eleven pennyweights twelve grains fine, or containing this weight of pure silver, and twelve grains of alloy in twelve pennyweights; six parts of lead for silver of eleven pennyweights; eight parts lead for silver of ten pennyweights; ten parts lead for silver of nine pennyweights; and so on in the same progression.

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* 1½ gross. Though these doses of silver and lead appeared to be proper for all operations of assaying gold, the commissaries observe, nevertheless, that gold of a lower title than eighteen carats may be alloyed with two parts, and even less, of silver; in order that the small mass of metal, when it comes to be laminated, may not be too thin, so as to break in pieces during the parting.

Assay Table, by M. D'Arcet.

Titles of the silver.	Quantities of copper in the alloy.	Doses of lead necessary, the weight of silver being 1.	Relation between the lead and copper.
Silver at 1000	0	3-10ths	
950	50	3	70 to 1
900	100	7	60 to 1
800	200	10	50 to 1
700	300	12	40 to 1
600	400	14	35 to 1
500	500	from 16 to 17	32 to 1
400	600	16—17	26.66 to 1
300	700	16—17	22.857 to 1
200	800	16—17	20 to 1
100	900	16—17	17.77 to 1
Pure Copper,	1000	16—17	16 to 1

This table supposes, that the title of the silver to be assayed is known; but when it is not, it may be determined approximately, by exposing in the cupel 0.1 part of this silver with 1 of lead. French gold and silver coin contains 1-10th of copper united to the precious metal. British silver coin consists of $12\frac{1}{3}$ silver and 1 copper; our gold coin contains 11-12ths of gold. The remainder is either copper, or a mixture of silver and copper.

ASTRINGENT PRINCIPLE. The effect called astringency, considered as distinguishable by the taste, is incapable of being defined. It is perceived in the husks of nuts, of walnuts, in green tea, and eminently in the nut gall. This is probably owing to the circumstance, that acids have likewise the property of corrugating the fibres of the mouth and tongue, which is considered as characteristic of astringency as it relates to taste; and hence the gallic acid, which is commonly found united with the true astringent principle, was long mistaken for it. Seguin first distinguished them, and, from the use of this principle in tanning skins, has given it the name of *tannin.* Their characteristic differences are, the gallic acid forms a black precipitate with iron; the astringent principle forms an insoluble compound with albumen. See Tannin.

ATACAMITE. A native muriate of copper. See Ores.

ATHANOR. A kind of furnace, which has long since fallen into disuse. The very long and durable operations of the ancient chemists rendered it a desirable requisite, that their fires should be constantly supplied with fuel in proportion to the consumption. The athanor furnace was peculiarly adapted to this purpose. Beside the usual parts, it was provided with a hollow tower, into which charcoal was put. The upper part of the tower, when filled, was closely shut by a well-fitted cover; and the lower part communicated with the fire-place of the furnace. In consequence of this disposition, the charcoal subsided into the fire-place gradually as the consumption made room for it; but that which was contained in the tower was defended from combustion by the exclusion of a proper supply of air.

ATMOMETER. The name of an instrument contrived by Professor Leslie, to measure the quantity of exhalation from a humid surface in a given time. It consists of a thin ball of porous earthen-ware, two or three inches in diameter, with a small neck, to which is firmly cemented a long and rather wide tube of glass, bearing divisions, each of them corresponding to an internal annular section, equal to a film of liquid that would cover the outer surface of the ball to the thickness of the thousandth part of an inch. These divisions are ascertained by a simple calculation, and numbered downwards to the extent of 100 or 200. To the top of the tube is fitted a brass cap, having a collar of leather, and which, after the cavity has been filled with distilled or boiled water, is screwed tight. The outside of the ball being now wiped dry, the instrument is suspended out of doors, and exposed to the free action of the air. The quantity of evaporation from a wet ball is the same as from a circle having twice the diameter of the sphere. In the atmometer, the humidity transudes through the porous substance, just as fast as it evaporates from the external surface; and this waste is measured by the corresponding descent of water in the stem. At the same time, the tightness of the collar taking off the pressure of the column of liquid, prevents it from oozing so profusely as to drop from the ball; an inconvenience which, in the case of very feeble evaporation, might otherwise take place. As the process goes on, a corresponding portion of air is likewise imbibed by the moisture on the outside, and being introduced into the ball, rises in a small stream to replace the water. The rate of evaporation is nowise affected by the quality of the porous ball. It continues exactly the same when the exhaling surface appears almost dry, and when it glistens with superfluous moisture. When the consumption of water is excessive, it may be allowed to percolate by unscrewing the cap, taking care, however, to let no drops fall.

In a review of Leslie's Meteorology, published in the Journal of Science for October 1822, the writer recommends a vessel of porous earthen-ware, of a given surface, filled with water, to be poised at the end of a balance, and the loss of weight which it suffers by evaporation in a given time to be noted. A thermometer being inserted into the mouth of the vessel, will indicate the temperature of the evaporating mass; and would form at the same time a good hygrometer, on Dr. Black's principle, that the degree of cold generated by evaporation is proportional to the dryness of the air.

ATMOSPHERE. See AIR (ATMOSPHERICAL).

ATOMIC THEORY. See EQUIVALENTS (CHEMICAL).

ATROPIA. A poisonous vegetable principle, probably alkaline, recently extracted from the *Atropa belladonna*, or deadly nightshade, by M. Brandes.

He boiled two pounds of dried leaves of atropa belladonna in a sufficient quantity of water, pressed the decoction out, and boiled the remaining leaves again in water. The decoctions were mixed, and some sulphuric acid was added in order to throw down the albumen and similar bodies; the solution is thus rendered thinner, and passes more readily through the filter. The decoction was then supersaturated with potash, by which he obtained a precipitate that, when washed with pure water and dried, weighed 89 grains. It consisted of small crystals, from which, by solution in acids, and precipitation by alkalis, the new alkaline substance, atropia, was obtained in a state of purity.

The external appearance of atropia varies considerably, according to the different methods by which it is obtained. When precipitated from the decoction of the herb by a solution of potash, it appears in the form of very small short crystals, constituting a sandy powder. When thrown down by ammonia from an aqueous solution of its salts, it appears in flakes like wax, if the solution is much diluted; if concentrated, it is gelatinous like precipitated alumina; when obtained by the cooling of a hot solution in alcohol, it crystallizes in long, acicular, transparent, brilliant crystals, often exceeding one inch in length, which are sometimes feathery, at other times star-like in appearance, and sometimes they are single crystals. Atropia, however, is obtained in such a crystalline state only when rendered perfectly pure by repeated solution in muriatic acid, and precipitation by ammonia. When pure, it has no taste. Cold water has hardly any effect upon dried atropia, but it dissolves a small quantity when it is recently precipitated; and boiling water dissolves still more. Cold alcohol dissolves but a minute portion of atropia; but when boiling, it readily dissolves it. Ether and oil of turpentine, even when boiling, have little effect on atropia.

Sulphate of atropia crystallizes in rhomboidal tables and prisms with square bases. It is soluble in four or five parts of cold water. It seems to effloresce in the air, when freed as much as possible from adhering sulphuric acid, by pressure between the folds of blotting paper. Its composition by Mr. Brandes seems to be,

Atropia,	38.93
Sulphuric acid,	36.52
Water,	24.55
	100.00

This analysis would make the prime equivalent of atropia so low as 5.3, oxygen being 1. Muriate of atropia appears in beautiful white brilliant crystals, which are either cubes or square plates similar to the muriate of *daturia*. He makes the composition of this salt to be,

Atropia,	39.19
Muriatic acid,	25.40
Water,	35.41
	100.00

This analysis was so conducted as to be entitled to little attention. Nitric, acetic, and oxalic acids dissolve atropia, and form acicular salts, all soluble in water and alcohol. Mr. Brandes was obliged to discontinue his experiments on the properties of this alkali. The violent headachs, pains in the back, and giddiness, with frequent nausea which the vapour of atropia occasioned while he was working on it, had such a bad effect on his weak health, that he has entirely abstained from any further experiments.

He once tasted a small quantity of sulphate of atropia. The taste was not bitter, but merely saline; but there soon followed violent headach, shaking in the limbs, alternate sensations of heat and cold, oppression of the chest and difficulty in breathing, and diminished circulation of the blood. The violence of these symptoms ceased in half an hour. Even the vapour of the different salts of atropia produces giddiness. When exposed for a long time to the vapours of a solution of nitrate, phosphate, or sulphate of atropia, the pupil of the eye is dilated. This happened frequently to him, and when he tasted the salt of atropia, it occurred to such a degree, that it remained so for twelve hours, and the different degrees of light had no influence. *Schweigger's Journal*, xxviii. 1.

We may observe on the above, that it is highly improbable that atropia should have a saturating power, intermediate between potash and soda. See BELLADONNA.

ATTRACTION. The instances of attraction which are exhibited by the phenomena around us, are exceedingly numerous, and continually present themselves to our observation. The effect of gravity, which causes the weight of bodies, is so universal, that we can scarcely form an idea how the universe could subsist without it. Other attractions, such as those of magnetism and electricity, are likewise observable; and every experiment in chemistry tends to show, that bodies are composed of various principles or substances, which adhere to each other with various degrees of force, and may be separated by known methods. It is a question among philosophers, whether all the attractions which obtain between bodies be referable to one general cause modified by circumstances, or whether various original and distinct causes act upon the particles of bodies at one and the same time. The philosophers at the beginning of the present century were disposed to consider the several attractions as essentially different, because the laws of their action differ from each other; but the moderns appear disposed to generalize this subject, and to consider all the attractions which exist between bodies, or at least those which are permanent, as depending upon one and the same cause, whatever it may be, which regulates at once the motions of the immense bodies that circulate through the celestial spaces, and those minute particles that are transferred from one combination to another in the operations of chemistry. The earlier philosophers observed, for example, that the attraction of gravitation acts upon bodies with a force which is inversely as the squares of the distances; and from mathematical deduction they have inferred, that the law of attraction between the particles themselves follows the same ratio; but when their observations were applied to bodies very near each other, or in contact, an adhesion took place, which is found to be much greater than could be deduced from that law applied to the centres of gravity. Hence they concluded, that the cohesive attraction is governed by a much higher ratio, and probably the cubes of the distances. The moderns, on the contrary, among whom are Bergman, Guyton Morveau, and others, have remarked, that these deductions are too general, because, for the most part, drawn from the consideration of spherical bodies, which admit of no contact but such as is indefinitely small, and exert the same powers on each other, whichever side may be obverted. They remark, likewise, that the consequence depending on the sum of the attractions in bodies not spherical, and at minute distances from each other, will not follow the inverted ratio of the square of the distance taken from any point assumed as the centre of gravity, admitting the particles to be governed by that law; but that it will greatly differ, according to the sides of the solid which are presented to each other, and their respective distances; insomuch that the attractions of certain particles indefinitely near each other will be indefinitely increased, though the ratio of the powers acting upon the remoter particles may continue nearly the same.

This doctrine, which however requires to be much more strictly examined by the application of mathematical principles, obviously points to a variety of interesting consequences. The polarity of particles, or their disposition to present themselves in their approach to each other in certain aspects, though it has been treated as a chimerical notion by a few writers, is one of the first of these results.

These are speculations which, with regard to the present state of chemistry, stand in much the same situation as the theory of gravity, which is minutely described in Plutarch, did with regard to astronomy before the time of Newton. As the celestial phenomena were formerly arranged from observation merely, but are now computed from the physical cause, gravitation; so, at present, chemistry is the science of matter of fact duly arranged, without the assistance of any extensive theory immediately deduced from the figures, volumes, densities, or mutual actions of the particles of bodies. What it may hereafter be, must depend on the ability and research of future chemists; but at present we must dismiss this remoter part of theory, to attend more immediately to the facts.

That the parts of bodies do attract each other is evident from that adhesion which produces solidity, and requires a certain force to overcome it. For the sake of perspicuity, the various effects of attraction have been considered as different kinds of affinity or powers. That power which physical writers call the attraction of cohesion, is generally called the attraction of aggregation by chemists. Aggregation is considered as the adhesion of parts of the same kind. Thus a number of pieces of brimstone united by fusion form an aggregate, the parts of which may be separated again by mechanical means. These parts have been called integrant parts; that is to say, the minutest parts into which a body can be divided, either really or by the imagination, so as not to change its nature, are called integrant parts. Thus, if sulphur and an alkali be combined together, and form liver of sulphur, we may conceive the mass to be divided and subdivided to an extreme degree, until at length the mass consists of merely a particle of brimstone and a particle of alkali. This then is an integrant part; and if it be divided further, the effect which chemists call decomposition will take place; and the particles, consisting no longer of liver of sulphur, but of sulphur alone, and alkali alone, will be what chemists call component parts or principles.

The union of bodies in a gross way is called mixture. Thus sand and an alkali may be mixed together. But when the very minute parts of a body unite with those of another so intimately as to form a body which has properties different from those of either of them, the union is called combination, or composition. Thus, if sand and an alkali be exposed to a strong heat, the minute parts of the mixture combine, and form glass.

The earlier chemists were very desirous of ascertaining the first principles or elements of bodies; and they distinguished by this name such substances as their art was incapable of rendering more simple. They seem however to have overlooked the obvious circumstance, that the limits of art are not the limits of nature. At present we hear little concerning elements. Those substances which we have not hitherto been able to analyze, or which, if decomposed, have hitherto eluded the observation of chemists, are indeed considered as simple substances relative to the present state of our knowledge, but in no other respect; for a variety of experiments give us reason to hope, that further inquiries may elucidate their nature and composition. Some writers, calling these simple substances by the name of Primary Principles, have distinguished compounds of these by the name of Secondary Principles, which they suppose to enter again into combinations without decomposition or change. It must be confessed, nevertheless, that no means have yet been devised to show whether any such subordination of principles exists. We may indeed discover, that a compound body consists of three or more principles; but whether two of these be previously united, so as to form a simple substance with relation to the third, or what in other respects may be their arrangement, we do not know. That it does exist, however, seems clear by making combinations in varied orders. Thus a weak solution of alkali will not dissolve oil; but a combination of oil and alkali will not separate by the addition of water. The alkali therefore adheres to that with which it was first combined. See also the article VEGETABLES.

If two solid bodies, disposed to combine together, be brought into contact with each other, the particles which touch will combine, and form a compound; and if the temperature at which this new compound assumes the fluid form be higher than the temperature of the experiment, the process will go no farther, because this new compound being interposed between the two bodies, will prevent their further access to each other; but if, on the contrary, the freezing point of the compound be lower than this temperature, liquefaction will ensue; and the fluid particles being at liberty to arrange themselves according to the law of their attractions, the process will go on, and the whole mass will gradually be converted into a new compound in the fluid state. An instance of this may be exhibited by mixing common salt and perfectly dry pounded ice together. The crystals of the salt alone will not liquefy unless very much heated; the crystals of the water, that is to say, the ice, will not liquefy unless heated as high as thirty-two degrees of Fahrenheit; and we have of course supposed the temperature of the experiment to be lower than this, because our water is in the solid state. Now it is a well known fact, that brine, or the saturated solution of sea salt in water, cannot be frozen unless it be cooled thirty-eight degrees lower than the freezing point of pure water. It follows then, that, if the temperature of the experiment be higher than this, the first combinations of salt and ice will produce a fluid brine, and the combination will proceed until the temperature of the mass has gradually sunk as low as the freezing point of brine; after which it would cease if it were not that surrounding bodies continually tend to raise the temperature. And accordingly it is found by experiment, that if the ice and the salt be previously cooled below the temperature of freezing brine, the combination and liquefaction will not take place. See CALORIC.

The instances in which solid bodies thus combine together not being very numerous, and the fluidity which ensues immediately after the commencement of this kind of expement, have induced several chemists to consider fluidity in one or both of the bodies applied to each other, to be a necessary circumstance, in order that they may produce chemical action upon each other. *Corpora non agunt nisi sint fluida.*

If one of two bodies applied to each other be fluid at the temperature of the experiment, its parts will successively unite with the parts of the solid, which will by that means be suspended in the fluid, and disappear. Such a fluid is called a solvent or menstruum; and the solid body is said to be dissolved.

Some substances unite together in all proportions. In this way the acids unite with water. But there are likewise many substances which cannot be dissolved in a fluid, at a settled temperature, in any quantity beyond a certain portion. Thus, water will dissolve only about one-third of its weight of common salt; and if more salt be added, it will remain solid. A fluid which holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance is so far from preventing a fluid from dissolving another body, that it very frequently happens, that the solvent power of the compound exceeds that of the original fluid itself. Chemists likewise use the word saturation in another sense; in which it denotes, such a union of two bodies as produces a compound the most remote in its properties from the properties of the component parts themselves. In combinations where one of the principles predominates, the one is said to be supersaturated, and the other principle is said to be subsaturated.

Heat in general increases the solvent power of fluids, probably by preventing part of the dissolved substance from congealing, or assuming the solid form.

It often happens, that bodies which have no tendency to unite are made to combine together by means of a third, which is then called *the medium*. Thus water and fat oils are made to unite by the medium of an alkali, in the combination called soap. Some writers, who seem desirous of multiplying terms, call this tendency to unite *the affinity of intermedium*. This case has likewise been called *disposing affinity;* but Berthollet more properly styles it *reciprocal affinity*. He likewise distinguishes affinity into *elementary*, when it is between the elementary parts of bodies; and *resulting* when it is a compound only, and would not take place with the elements of that compound.

It very frequently happens, on the contrary, that the tendency of two bodies to unite, or remain in combination together, is weakened or destroyed by the addition of a third. Thus alcohol unites with water in such a manner as to separate most salts from it. A striking instance of this is seen in a saturated or strong solution of nitre in water. If to this there be added an equal measure of alcohol, the greater part of the nitre instantly falls down. Thus magnesia is separated from a solution of Epsom salt, by the addition of an alkali, which combines with the sulphuric acid, and separates the earth. The principle which falls down is said to be precipitated, and in many instances is called a precipitate. Some modern chemists use the term precipitation in a more extended, and rather forced sense; for they apply it to all substances thus separated. In this enunciation, therefore, they would say, that potash precipitates soda from a solution of common salt, though no visible separation or precipitation takes place; for the soda, when disengaged from its acid, is still suspended in the water by reason of its solubility.

From a great number of facts of this nature, it is clearly ascertained, not as a probable hypothesis, but as simple matter of fact, that some bodies have a stronger tendency to unite than others; and that the union of any substance with another will exclude, or separate, a third substance, which might have been previously united with one of them; excepting only in those cases wherein the new compound has a tendency to unite with that third substance, and form a triple compound. This preference of uniting, which a given substance is found to exhibit with regard to other bodies, is by an easy metaphor called elective attraction, and is subject to a variety of cases, according to the number and the powers of the principles which are respectively presented to each other. The cases which have been most frequently observed by chemists are those called simple elective attractions, and double elective attractions.

When a simple substance is presented or applied to another substance compounded of two principles, and unites with one of these two principles so as to separate or exclude the other, this effect is said to be produced by simple elective attraction.

It may be doubted whether any of our operations have been carried to this degree of simplicity. All the chemical principles we are acquainted with are simple only with respect to our power of decomposing them; and the daily discoveries of our contemporaries tend to decompose those substances, which chemists a few years ago considered as simple. Without insisting, however, upon this difficulty, we may observe, that water is concerned in all the operations which are called humid, and beyond a doubt modifies all the effects of such bodies as are suspended in it; and the variations of temperature, whether arising from an actual igneous fluid, or from a mere modification of the parts of bodies, also tend greatly to disturb the effects of elective attraction. These causes render it difficult to point out an example of simple elective attraction, which may in strictness be reckoned as such.

Double elective attraction takes place when two bodies, each consisting of two principles, are presented to each other, and mutually exchange a principle of each; by which means two new bodies, or compounds, are produced, of a different nature from the original compounds.

Under the same limitations as were pointed out in speaking of simple elective attraction, we may offer instances of double elective attraction. Let oxide of mercury be dissolved to saturation in the nitric acid, the water will then contain nitrate of mercury. Again, let potash be dissolved to saturation in the sulphuric acid, and the result will be a solution of sulphate of potash. If mercury were added to the latter solution, it would indeed tend to unite with the acid, but would produce no decomposition; because the elective attraction of the acid to the alkali is the strongest. So likewise, if the nitric acid alone be added to it, its tendency to unite with the alkali, strong as it is, will not effect any change, because the alkali is already in combination with a stronger acid. But if the nitrate of mercury be added to the solution of sulphate of potash, a change of principles will take place: the sulphuric acid will quit the alkali, and unite with the mercury, while the nitric acid combines with the alkali; and these two new salts, namely, nitrate of potash, and sulphate of mercury, may be obtained separately by crystallization.

The most remarkable circumstance in this process is, that the joint effects of the attractions of the sulphuric acid to mercury, and the nitric acid to alkali, prove to be stronger than the sum of the attractions between the sulphuric acid and the alkali, and between the nitric acid and the mercury; for if the sum of these two last had not been weaker, the original combinations would not have been broken.

Mr. Kirwan, who first, in the year 1782, considered this subject with that attention it deserves, called the affinities which tend to preserve the original combinations, the quiescent affinities. He distinguished the affinities or attractions which tend to produce a change of principles, by the name of the divellent affinities.

Some eminent chemists are disposed to consider as effects of double affinities, those changes of principles only which would not have taken place without the assistance of a fourth principle. Thus, the mutual decomposition of sulphate of soda and nitrate of potash, in which the alkalis are changed, and sulphate of potash and nitrate of soda are produced, is not considered by them as an instance of double decomposition; because the nitre would have been decomposed by a simple elective attraction, upon the addition of the acid only.

There are various circumstances which modify the effects of elective attraction, and have from time to time misled chemists in their deductions. The chief of these is the temperature, which, acting differently upon the several parts of compounded bodies, seldom fails to alter, and frequently reverses the effects of the affinities. Thus, if alcohol be added to a solution of nitrate of potash, it unites with the water, and precipitates the salt at a common temperature. But if the temperature be raised, the alcohol rises on account of its volatility, and the salt is again dissolved. Thus again, if sulphuric acid be added, in a common temperature, to a combination of phosphoric acid and lime, it will decompose the salt, and disengage the phosphoric acid; but if this same mixture of these principles be exposed to a considerable heat, the sulphuric acid will have its attraction to the lime so much diminished, that it will rise, and give place again to the phosphoric, which will combine with the lime. Again, mercury kept in a degree of heat very nearly equal to volatilizing it, will absorb oxygen, and become converted into the red oxide formerly called precipitate *per se;* but if the heat be augmented still more, the oxygen will assume the elastic state, and fly off, leaving the mercury in its original state. Numberless instances of the like nature continually present themselves to the observation of chemists, which are sufficient to establish the conclusion, that the elective attractions are not constant but at one and the same temperature.

Many philosophers are of opinion, that the variations produced by change of temperature arise from the elective attraction of the matter of heat itself. But there are no decisive experiments either in confirmation or refutation of this hypothesis.

If we except the operation of heat, which really produces a change in the elective attractions, we shall find, that most of the other difficulties attending this subject arise from the imperfect state of chemical science. If to a compound of two principles a third be added, the effect of this must necessarily be different according to its quantity, and likewise according to the state of saturation of the two principles of the compounded body. If the third principle which is added be in excess, it may dissolve and suspend the compound which may be newly formed, and likewise that which might have been precipitated. The metallic solutions, decomposed by the addition of an alkali, afford no precipitate in various cases when the alkali is in excess; because this excess dissolves the precipitate, which would else have fallen down. If, on the other hand, one of the two principles of the compound body be in excess, the addition of a third substance may combine with that excess, and leave a neutral substance, exhibiting very different properties from the former. Thus, if cream of tartar, which is a salt of difficult solubility, consisting of potash united to an excess of the acid of tartar, be dissolved in water, and chalk be added, the excess unites with part of the lime of the chalk, and forms a scarcely soluble salt; and the neutral compound, which remains after the privation of this excess of acid, is a very soluble salt, greatly differing in taste and properties from the cream of tartar. The metals and the acids likewise afford various phenomena, according to their degree of oxidation. A determinate oxidation is in general necessary for the solution of metals in acids; and the acids themselves act very differently, accordingly as they are more or less acidified. Thus, the nitrous acid gives place to acids which are weaker than the nitric acid: the sulphurous acid gives place to acids greatly inferior in attractive power or affinity to the sulphuric acid. The deception arising from effects of this nature is in a great measure produced by the want of discrimination on the part of chemical philosophers; it being evident that the properties of any compound substance depend as much upon the proportion of its ingredients, as upon their respective nature.

The presence and quantity of water is probably of more consequence than is yet supposed. Thus, bismuth is dissolved in nitric acid, but falls when the water is much in quantity. The same is true of antimony. Ribaucout has shown the last (Annales de Chimie, xv. 122.) in alum, and it is likely that the fact is more common than is suspected. Whether the attraction and strength, as to quantity in saturation, be not variable by the presence or absence of water, must be referred to experiment.

The power of double elective attractions too is disturbed by this circumstance: If muriate of lime be added to a solution of carbonate of soda, they are both decomposed, and the results are muriate of soda and carbonate of lime. But if lime and muriate of soda be mixed with just water sufficient to make them into a paste, and this be exposed to the action of carbonic acid gas, a saline efflorescence consisting of carbonate of soda will be formed on the surface, and the bottom of the vessel will be occupied by muriate of lime in a state of deliquescence.

M. Berthollet made a great number of experiments, from which he deduced the following law:—that in elective attractions the power exerted is not in the ratio of the affinity simply, but in a ratio compounded of the force of affinity and the quantity of the agent; so that quantity may compensate for weaker affinity. Thus an acid which has a weaker affinity than another for a given base, if it be employed in a certain quantity, is capable of taking part of that base from the acid which has a stronger affinity for it; so that the base will be divided between them in the compound ratio of their affinity and quantity. This division of one substance between two others, for which it has different affinities, always takes place, according to him, when three such are present under circumstances in which they can mutually act on each other. And hence it is, that the force of affinity acts most powerfully when two substances first come into contact, and continues to decrease in power as either approaches the point of saturation. For the same reason it is so difficult to separate the last portions of any substance adhering to another. Hence, if the doctrine laid down by M. Berthollet be true, to its utmost extent, it must be impossible ever to free a compound completely from any one of its constituent parts by the agency of elective attraction; so that all our best established analyses are more or less inaccurate.

The solubility or insolubility of principles, at the temperature of any experiment, has likewise tended to mislead chemists, who have deduced consequences from the first effects of their experiments. It is evident, that many separations may ensue without precipitation; because this circumstance does not take place unless the separated principle be insoluble, or nearly so. The soda cannot be precipitated from a solution of sulphate of soda by the addition of potash, because of its great solubility; but, on the contrary, the new compound itself, or sulphate of potash, which is much less soluble, may fall down, if there be not enough water present to suspend it. No certain knowledge can therefore be derived from the appearance or the want of precipitation, unless the products be carefully examined. In some instances all the products remain suspended, and in others they all fall down, as may be instanced in the decomposition of sulphate of iron by lime. Here the acid unites with the lime, and forms sulphate of lime, which is scarcely at all soluble; and the still less soluble oxide of iron, which was disengaged, falls down along with it.

Many instances present themselves, in which decomposition does not take place, but a sort of equilibrium of affinity is perceived. Thus, soda, added to the supertartrate of potash, forms a triple salt by combining with its excess of acid. So likewise ammonia combines with a portion of the acid of muriate of mercury, and forms the triple compound formerly distinguished by the barbarous name of sal alembroth.

When we reflect maturely upon all the circumstances enumerated, or slightly touched upon, in the foregoing pages, we may form some idea of the extensive field of research which yet remains to be explored by chemists. If it were possible to procure simple substances, and combine two together, and to this combination of two to add one more of the other simple substances, the result of the experiment would in many cases determine, by the exclusion of one of the three, that its affinity to either of the remaining two was less than that between those two respectively. In this way it would be ascertained, in the progress of experimental inquiry, that the simple attractions of a series of substances were gradually increasing or diminishing in strength. Thus, ammonia separates alumina from the sulphuric acid; magnesia, in like manner, separates the ammonia; lime predominates, in the strength of affinity, over magnesia, as appears by its separating this last earth; the soda separates the lime, and itself gives place to the potash; and, lastly, potash yields its acid to barytes. The simple elective attractions of these several substances to sulphuric acid are therefore in the inverted order of their effects: barytes is the strongest; and this is succeeded regularly by potash, soda, lime, magnesia, ammonia, and alumina. It is evident, that results of this nature, being tabulated, as was first done by the celebrated Geoffroy, and afterward by Bergman, must afford a valuable mass of chemical knowledge. It must be remarked, however, that these results merely indicate, that the powers are greater or less than each other; but how much greater or less is not determined, either absolutely or relatively. Tables of this nature cannot therefore inform us of the effects which may take place in the way of double affinity, for want of the numerical relations between the attracting powers. Thus, when we are in possession of the order of the simple elective attractions between the sulphuric acid and a series of substances, and also between the nitric acid and the same substances; and when, in addition to this, the respective powers of each of the acids upon every one of the substances singly taken, are known, so far as to determine which will displace the other; yet we cannot thence foretell the result of applying two combinations to each other, each containing an acid united with one of the number of simple substances. Or, more concisely, a table of simple elective attractions can be of no use to determine the effects of double elective attraction, unless the absolute power of the attractions be expressed by number instead of their order merely.

It has been often remarked, that the action of a substance is diminished in proportion as it approaches to a state of saturation; and this diminution of power has been employed to explain several chemical phenomena. It is likewise known, that the resistance found in expelling a substance from the last portions of a combination, either by affinity or heat, is much greater than at the commencement of the decomposition, and sometimes such, that its entire decomposition cannot be effected. Thus the black oxide of manganese, exposed to heat, will part with only a certain definite quantity of its oxygen. No degree of heat can expel the whole.

According to Berthollet, when two substances are in competition to combine with a third, each of them obtains a degree of saturation proportionate to its affinity multiplied by its quantity; a product which he denominates *mass*. The subject of the combination divides its action in proportion to the masses, and by varying the latter, this illustrious chemist thinks, that the results also will be varied. The following are the forces which he regards as exercising a great influence upon chemical combinations and phenomena, by concurring with or opposing the mutual affinity of the substances brought into action. 1. The action of solvents, or the affinity which they exert according to their proportion. Thus, if into a very dilute solution of muriate of lime, a solution of sulphate of soda be poured, no precipitate of sulphate of lime will happen, though the quantity of the solvent water be less than is necessary to dissolve the calcareous sulphate. If the same two saline solutions be mixed with less water, the sulphate of lime will fall in a few seconds, or a few minutes, according to the strength of the mingled solutions. 2. The force of cohesion, which is the effect of the mutual affinity of the particles of a substance or combination. Hence we can easily see why a solution of pure potash, which so readily dissolves pulverulent alumina, has no effect on alumina concreted and condensed in the oriental gems. The lowest red heat kindles charcoal, or determines its combination with atmospherical oxygen; but a much higher temperature is requisite to burn the same carbonaceous matter, more densely aggregated in the diamond. 3. Elasticity, whether natural or produced by heat; which has, by some, been considered as the affinity of caloric. Of the influence of this power a fine illustration is afforded by muriate of lime and carbonate of ammonia. When a solution of the latter salt is poured into one of the former, a double decomposition instantly takes place: carbonate of lime falls to the bottom in powder, and muriate of ammonia floats above. Let this liquid mixture be boiled for some time; exhalation of ammoniacal gas will be perceived by the nostrils, and the carbonate of lime will be redissolved; as may be proved by the further addition of carbonate of ammonia. This will cause an earthy precipitate from the liquid, which prior to ebullition was merely muriate of ammonia. 4. Efflorescence, a power which acts only under very rare circumstances. It is exemplified in the natron lakes of Egypt; on the margin of which, according to Berthollet, carbonate of lime decomposes muriate of soda, in consequence of the efflorescing property of the resulting carbonate. 5. Gravity likewise exerts its influence, particularly when it produces the compression of elastic fluids; but it may always without inconvenience be confounded with the force of cohesion.

M. Berthollet thinks, that as the tables of affinity have all been constructed upon the supposition that substances possess different degrees of affinity, which produce the decompositions and combinations that are formed, independently of the proportions and other conditions which contribute to the results, these tables are calculated to give but a false idea of the degrees of chemical action of the substances arranged in them. "The denomination of *elective* affinity," says he, "is in itself erroneous, since it supposes the union of one entire substance with another, in preference to a third, while there is only a division of action, subjected to other chemical conditions." The force of cohesion, which was formerly considered merely as an obstacle to solution, limits not only the quantities of substances which may be brought into action in a liquid, and consequently modifies the conditions of the saturation which follows; but it is the power which causes the precipitations and crystallizations that take place, and determines the proportions of such combinations as are made by quitting the liquid: it is this force which sometimes even produces the separation of a substance, without its forming any combination with another substance, as has been remarked in metallic precipitations. Elasticity acts by producing effects opposite to those of cohesion, and which consists either in withdrawing some substances from the action of others in a liquid, or in diminishing the proportion which exists within the sphere of activity; but when all the substances are in the elastic state, their action is subjected to the same conditions. If tables were formed which would represent the disposition to insolubility or volatility, in the different combinations, they would serve to explain a great number of combinations which take their origin from the mixture of different substances, and from the influence of heat. These considerations need not prevent us, says Berthollet, from using the term affinity to denote the whole chemical power of a body exerted in a given situation, even by its present constitution, its proportion, or even by the concurrence of other affinities; but we must avoid considering this power as a constant force, which produces compositions and decompositions. All substances, according to him, exert a mutual action during the time they are in the liquid state; so that in a solution, for example, of sulphate of potash and muriate of soda, these two salts are not distinct, while there is no cause to determine the separation from their combination; but there exists in this liquid, sulphuric acid, muriatic acid, soda, and potash. In like manner, when the proper quantity of carbonate of potash is added to muriate of soda, the mingled solution does not consist of carbonate of soda and muriate of potash, resulting from complex affinity, but contains simply muriatic and carbonic acids with potash and soda, in quadruple union and saturation. It is the crystallizing property of the soda carbonate, which, after due evaporation, determines the definite decomposition, and not any power of elective attraction. Or generally, when one substance separates from a combination by the introduction of another, it is not merely from being supplanted by the superior affinity of an antagonist, but because its intrinsic tendency to the solid or gaseous form educes it from its former associate. There is certainly much truth in this proposition of Berthollet.

But with regard to the indefinite partition of a base between two rival acids, and of an acid between two rival bases, a doctrine which that profound philosopher laboured to establish by a wide experimental induction, many facts of an irreconcileable nature occur. Sir H. Davy has remarked, with his usual good judgment, that were this proposition correct, it is evident that there could be scarcely any definite proportions: a salt crystallizing in a strong alkaline solution would be strongly alkaline; in a weak one, less alkaline; while in an acid solution it would be acid. But this does not seem to be the case. In combinations of gaseous bodies, whose constitution gives their particles perfect freedom of motion, the proportions are definite and unchangeable, however we may change the proportions of the aeriform mixture. And in all solid compounds that have been accurately examined, in which there is no chance of mechanical mixture, the same law seems to prevail. Different bodies may indeed be dissolved in different menstrua in very various proportions, but the result may be regarded as a mixture of different solutions, rather than a combination. With regard to glasses and metallic alloys, adduced by Berthollet, it is sufficient to know that the points of fusion of alkali, glass, and oxides of lead and tin, are so near each other, that transparent *mixtures* of them may be formed. The attractive power of matter is undoubtedly general, but in the formation of aggregates certain definite arrangements take place. Bergman observed long ago, that when nitric acid was digested on sulphate of potash, a portion of nitre was formed, in apparent contradiction to the superior affinity which he had assigned to sulphuric acid for the potash. But he also gave what appears to be a satisfactory explanation of this seeming anomaly, which Berthollet has adduced in support of his views of indefinite and universal partition.

Sulphuric acid tends to combine in two distinct but definite proportions with potash, forming the neutral sulphate and the bisulphate. Nitric acid may therefore abstract from the neutral salt, that portion of potash which it should lose to pass into the acidulous salt; but it will not deprive it of any more. Hence this very example is decidedly adverse to the indefinite combinations and successive partitions taught by Berthollet. The above decomposition resolves itself evidently, therefore, into a case of double affinity. That a large quantity of pure potash can separate a little sulphuric acid from the sulphate of barytes, has been stated by Berthollet; but it is a circumstance difficult to demonstrate. If the operation be conducted with access of air, then carbonate of potash is readily formed, and a well known double affinity comes into play, viz. that of barytes for carbonic acid on one hand, and of sulphuric acid for potash on the other. Supposing the agency of carbonic acid to be excluded, then are we to believe that the potash having become a soluble sulphate, exists in liquid union with pure barytes? See M. Dulong's experiments, further on.

When M. Berthollet separated a little potash from sulphuric acid by soda, he merely formed a little bisulphate of potash, while the free potash united to the water and alcohol, for which it has a strong affinity, and sulphate of soda was also formed. This, therefore, is a very intelligible case of compound attraction. According to M. Berthollet, whenever an earth is precipitated from a saline combination by an alkali, it should carry down with it a portion of its acid associate. But sulphate of magnesia acted on by potash, yields an earthy precipitate, which, after proper washing, betrays the presence of no retained sulphuric acid. The neutral salts of soda and potash part with none of their acid to magnesia, by the longest digestion in their solutions. If on the tartrate of lime, or oxalate of lead, the portion of sulphuric acid adequate to saturate these respective bases be poured, entire decomposition will be effected without any partition whatever. Now, sulphate of lime, which is the result in the first case, being actually a much more soluble salt than the tartrate, we should expect a portion of the latter to resist decomposition by the aid of its cohesive force. A plate of iron plunged into a solution of sulphate of copper, separates the whole of the latter metal. An equally absolute decomposition is effected by zinc on the saline solutions of lead and tin. The sum total of oxygen and acid is here transferred to the decomposing body, without any partition whatever.

We have already observed, that sulphate of barytes digested in a hot solution of carbonate of potash, gives birth to a portion of carbonate of barytes and sulphate of potash. But by M. Dulong's experiment, the reverse decomposition is possible, viz. carbonate of barytes being digested in solution of sulphate of potash, we obtain sulphate of barytes and carbonate of potash. Are we hence to infer, that sulphate of barytes and carbonate of potash, having for sometime amused the operator by the production of an alkaline sulphate and earthy carbonate, will change their mood, and, retracing their steps, restore things to their pristine condition, and thus in alternate oscillation for ever?

If chlorine gas be made to act on the oxides of mercury, tin, or antimony, it will unite to the metallic base, and displace every particle of the oxygen. Now, the resulting chlorides cannot owe their purity to any superiority of cohesive force which they possess over the oxides, which, on the contrary, are both denser and more fixed than the new compounds. Finally, if 25 parts of pure magnesia mixed with 35 of dry lime, be digested in 85 parts of nitric acid, sp. gr. 1.500 diluted with water, we shall find that the whole lime will be dissolved, but not a particle of the magnesia. On decanting the neutral calcareous nitrate, washing and drying the earthy residuum, we shall procure the 25 parts of magnesia unchanged.

We are, therefore, entitled to affirm, that affinity is elective, acting in the different chemical bodies with gradations of attractive force, liable however to be modified, as we have shown in the case of muriate of lime and carbonate of ammonia, by temperature, and other adventitious powers.

Decompositions which cannot be produced by single attractions, may be effected by double affinity; and that we may expect with the greater certainty, *a priori*, if one of the two resulting compounds of the double interchange naturally exists in the solid or aeriform state. And if the one resulting compound be solid and the other gaseous, then decomposition will be certain and complete. This applies with equal force to single affinities, or decompositions. Thus when sulphuric acid and muriate of lime in due proportions are exposed to heat, a perfect decomposition is accomplished, and pure sulphate of lime and muriatic acid gas are produced. But when the various mixed ingredients remain in *solution*, it is then reasonable to think with Berthollet, that a reciprocal attraction pervades the whole, modifying its nature and properties. Thus solution of sulphate of copper is blue, that of muriate of copper is green. Now, if into a solution of the former salt we pour muriatic acid, we shall observe this robbing the sulphuric acid of a quantity of the cupreous oxide, proportional to its mass; for the more muriatic acid we add, the greener will the liquid become. But if, by concentration, the sulphate of copper be suffered to crystallize, the phenomena change; a new force, that of crystallization, is superadded, which aids the affinity of the sulphuric acid, and decides the decomposition. The surplus of each of these acids is employed in counterbalancing the surplus of its antagonist, and need not be considered as combined with the copper. Here, however, we verge on the obscure and unproductive domain of chemical metaphysics, a region in which it is useless to expatiate.

M. Berthollet estimates the attractive forces or affinities of bodies of the same class, to be *inversely* as their saturating quantities. Thus, among acids, 50 parts of real sulphuric will saturate as much potash or soda as $67\frac{1}{2}$ of real nitric, and as $27\frac{1}{2}$ of carbonic. Thus, too, $21\frac{1}{4}$ of ammonia will saturate as much acid as 25 of magnesia, 35 of lime, and 60 of potash. Hence he infers that the carbonic acid is endowed with a higher affinity than the sulphuric; and this, than the nitric. The same proposition applies to ammonia, magnesia, lime, and potash. But in direct hostility to this doctrine, we have seen lime exercise a greater affinity for the acids than magnesia. And though M. Berthollet has ingeniously sought to explain away the difficulty about potash, ammonia, and carbonic acid, by referring to the solid or gaseous results of their action; yet it is hard to conceive of solidity operating in producing an effect, before solidity exists, and of elasticity operating while the substance is solid or liquid. On this point a good syllogism has been offered by Sir H. Davy. "The action," says this profound chemist, "between the constituents of a compound, must be mutual. Sulphuric acid, there is every reason to believe, has as much attraction for barytes, as barytes has for sulphuric acid, and barytes is the alkaline substance of which the largest quantity is required to saturate sulphuric acid; therefore, on M. Berthollet's view, it has the weakest affinity for that acid; but less sulphuric acid saturates this substance than any other earthy or alkaline body. Therefore, according to M. Berthollet, sulphuric acid has a stronger affinity for barytes than for any other substance; which is contradictory."

In the table of chemical equivalents (EQUIVALENTS, CHEMICAL) will be found a view of the definite proportions in which the various chemical bodies combine, referred to their primary or lowest numerical terms, vulgarly called the *weights* of the *atoms*.

Mr. Higgins, who first suggested the Atomic Theory, in promulgating its principles in his Comparative View of the Phlogistic and Antiphlogistic Hypotheses, connected their exposition with general views of the relative forces of affinity among the combining particles. These forces he illustrates by diagrams, to which I have adverted, in the article EQUIVALENTS (CHEMICAL). This joint consideration of combining *force*, and combining *ratio*, has been neglected by subsequent writers; whence, Mr. Higgins says, "The atomic doctrine has been applied by me in abstruse and difficult researches. Its application by Mr. Dalton has been in a general and popular way; and it is from these circumstances alone, that it gained the name of Dalton's Theory."

Since the chemical statics appeared, perhaps no chemist has contributed so many important facts to the doctrines of affinity as M. Dulong. His admirable inquiries concerning the mutual decomposition of soluble and insoluble salts were presented to the National Institute, and afterwards published in the Annales de Chimie, tom. 82; from which they were translated into the 35th and 36th volumes of Nicholson's Journal, and an abstract of them was given in the 41st vol. of the Phil. Mag.

After the labours of Bergman and Berthollet, chemistry seemed to leave little further to be desired, relative to the mutual decomposition of soluble salts. But the insoluble salts are likewise susceptible of exchanging their principles with a great number of the soluble salts. "This class of phenomena," says M. Dulong, "though almost as numerous as that which embraces the soluble salts, and capable of affording new resources to analysis, has not yet been examined in a general manner."

The action of the soluble carbonates on the insoluble salts is the only one which had been at all studied. Thus carbonates of potash and soda in solution had been employed conveniently to decompose sulphate of barytes. M. Dulong had an opportunity, in some particular researches, to observe a considerably extensive number of facts relating to the mutual decomposition of the soluble and insoluble salts, and endeavoured, he says, to determine the general cause of these phenomena, and the method of foreseeing their results, without being obliged to retain, by an effort of memory, of which few persons would be capable, all the direct observations which would be requisite to ascertain them.

M. Dulong found by experiment, that all the insoluble salts are decomposable by the carbonate of potash or the carbonate of soda, and in some instances with curious phenomena. When sulphate of barytes, phosphate of barytes, or oxalate of lime, is boiled with solution of bicarbonate, or carbonate of potash, a considerable part of the insoluble sulphate is constantly transformed into a carbonate of the same base; but on reaching a certain limit, the decomposition stopped, although there remained sometimes a very considerable quantity of the soluble carbonate not decomposed. M. Dulong convinced himself, that the different degrees of concentration of the alkaline solution, produced but very slight variations in the results of this decomposition. He took 10 grammes of dry subcarbonate of potash, and 7.66, being their equivalent proportion, of dry subcarbonate of soda; quantities containing each 3.07 grammes of carbonic acid. They were separately dissolved in 250 grammes of water, and each solution was kept in ebullition for two hours, on 8 grammes of the sulphate of barytes. On analyzing the two residues, it was found that the potash experiment yielded 2.185 grammes, and the soda only 1.833; or in the proportion of 6 to 5. Is this difference to be ascribed to the difference in the attractive forces of the two alkalis; to the more sparing solubility, or greater attractive force of the sulphate of potash; or to both causes conjointly?

Since the alkaline carbonates lose their decomposing agency when a certain proportion of the alkaline sulphate is formed, M. Dulong tried to ascertain the limits by the following experiment: 7 grammes of sulphate of potash, with 6 of subcarbonate, dissolved in 250 of water, were boiled with the sulphate of barytes for several hours, without the least trace of decomposition being evinced. The supernatant liquid, filtered, and boiled on carbonate of barytes, produced a considerable quantity of sulphate; but ceased acting before this sulphate of potash was exhausted. The same phenomena were obtained with carbonate and sulphate of soda. "Lastly, the sulphate of potash and the sulphate of soda alone, and perfectly neutral, re-acted likewise upon the carbonate of barytes, and produced on one part sulphate of barytes, but on the other the subcarbonate of potash or soda which remained in solution, together with the portion of the sulphate which resisted the decomposition. 20 grammes of crystallized sulphate of soda, and 10 grammes of sulphate of potash, were separately dissolved in 260 of water. Each solution was boiled for 2 hours on 20 grains of carbonate of barytes. The sulphate of soda produced 10.17 gr. of sulphate of barytes, and the sulphate of potash 9.87." Had 108 of sulphate of potash been employed, which is the true equivalent of 200 of sulphate of soda in crystals, a somewhat larger product would have been obtained than 9.87. This experiment, however, is most satisfactory with regard to the amount of decomposition. The mutual action of the insoluble carbonates, with the soluble salts, whose acids form, with the bases of these carbonates, insoluble salts, is equally general with that of the soluble carbonates on the insoluble salts. The following is M. Dulong's table of results:

Carbonate of Barytes.	Carbonate of Strontian.	Carbonate of Lime.	Carbonate of Lead.
Sulphate of Potash	Id.	0	Id.
———— Soda	Id.	0	Id.
———— Lime	Id.	0	Id.
———— Ammonia	Id.	Id.	Id.
———— Magnesia	Id.	....	Id.
Phosphate of Soda	Id.	Id.	Id.
———— Ammonia	Id.	Id.	Id.
Sulphite of Potash	Id.	Id.	Id.
Phosphite of Potash	Id.	Id.	Id.
———— Soda	Id.	Id.	Id.
———— Ammonia	Id.	Id.	Id.
Borate of Soda	Id.	....	Id.
Arseniate of Potash	Id.	Id.	Id.
———— Soda	Id.	Id.	Id.
Oxalate of Potash	Id.	Id.	Id.
———— Ammonia	Id.	Id.	Id.
Fluate of Soda	Id.	Id.	Id.
Chromate of Potash	Id.	Id.	Id.

All those salts which have ammonia for their base are completely decomposed by the insoluble carbonates found in the same column. The new insoluble salt replaces the carbonate which is decomposed, and the carbonate of ammonia flies off. Hence, if a sufficient quantity of insoluble carbonate be present, the liquid will become pure water.

When the soluble salt has an insoluble base, the decomposition does not meet with any obstacle, but continues until the liquid becomes mere water. Thus, solution of sulphate of magnesia, boiled with carbonate of barytes, will be resolved into an insoluble carbonate and sulphate, provided enough of carbonate of barytes be present. Otherwise a portion of the magnesian carbonate being dissolved in its own sulphate, gives alkaline properties to the solution.

If the base be metallic, it almost always forms a salt with excess of oxide, which being insoluble, precipitates.

The general inferences of M. Dulong's inquiries are the following: 1. That all the insoluble salts are decomposed by the subcarbonates of potash or soda, but that a mutual exchange of the principles of these salts cannot in any case be completely made; or in other words, that the decomposition of the subcarbonates is only partial. 2. That all the soluble salts, of which the acid forms, with the base of the insoluble carbonates, an insoluble salt, are decomposed by these carbonates, until the decomposition has reached a certain limit which it cannot pass.

When a soluble subcarbonate acts on an insoluble salt, in proportion as the carbonic acid is precipitated on the base of the insoluble salts, it is replaced in the solution by a quantity of another acid, capable of *completely* neutralizing the alkali. Thus, during the whole course of the decomposition, fresh quantities of *neutral* salt replace the corresponding quantities of an imperfectly saturated alkaline compound: and if we view the excess of alkaline power in the undecomposed subcarbonate, or its unbalanced capacity of saturation, as acting upon both acids, it is evident that in proportion as the decomposition advances, the liquid *approaches* more and more to the neutral state. In the inverse experiment, a contrary change supervenes. Each portion of the acid of the soluble salt, (sulphate of soda for example), which is precipitated on the base of the insoluble carbonate, is replaced by a quantity of carbonic acid, which forms, with the corresponding base, an alkaline subcarbonate: and the more of the first acid is precipitated upon the earthy base, the more subcarbonate the liquid contains, and the farther does its state *recede* from neutralization. This consideration seems to lead directly to the following theory of these decompositions.

It is known, says M. Dulong, that all the salts, even those which possess the greatest cohesion, yield to caustic potash or soda, a more or less considerable portion of their acid, according to circumstances. Now the alkaline subcarbonates may be considered as weak alkalis, which may take from all the insoluble salts a small quantity of their acids. This effect would soon be limited if the alkali were pure, in consequence of the resistance offered by the pure and soluble base. But the latter meeting in the liquid an acid with which it can form an insoluble salt, unites with it, and thus re-establishes the primitive conditions of the experiment. The same effects are produced successively on new portions of the bodies, till the degree of saturation of the liquid is in equilibrium with the cohesive force of the insoluble salt, so that the feebler this resistance may be, the more progress the decomposition will make. And again, when an insoluble carbonate is in contact with a neutral soluble salt, the base of the carbonate will tend to take part of the acid of the neutral salts; and if, from this union, an insoluble salt can result, the force of cohesion peculiar to this compound will determine the formation. The carbonic acid, released from the attraction of the earthy base by the fixed acid, instantly attaches itself to the surrounding alkali, forming a subcarbonate which replaces the decomposed neutral salt. The precipitation of the fixed acid on the insoluble carbonate, and the absorption of carbonic acid by the liquid, continues until the alkalinity thereby developed becomes so strong as to resist the precipitation of the acid; thus forming a counterpoise to the force by which that precipitation was accomplished. All action then ceases so that the more cohesion the insoluble salt possesses, the greater will be the proportion of acid taken from the soluble salt.

When the carbonate of potash can no longer decompose the sulphate of barytes, the carbonic acid which remains in the solution is to the sulphuric acid nearly in the ratio of 3 to 1; and when the sulphate of potash can no longer act upon the carbonate of barytes, these two acids are nearly in the ratio of 3 to 2; whence it follows, that the first liquor is much more alkaline than the second.

It is easy to account for this difference by examining the conditions of the equilibrium established in the two cases. When the sulphate of potash no longer decomposes the carbonate of barytes, it is because the excess of alkali, developed in the liquid, forms a counterpoise to the power with which sulphate of barytes tends to be produced in these circumstances. And when the subcarbonate of potash can no longer decompose the sulphate of barytes, it is because there is not such an excess of alkali in the liquid, as is capable of overcoming the cohesion and attraction between the elements of that salt. Now we know, that it requires a greater force to overcome an existing attractive power than to maintain the quiescent condition. Therefore the subcarbonate of potash ought to cease to decompose the sulphate of barytes, before the sulphuric and carbonic acids are in the same relation in which they are found, when the equilibrium is established by the inverse experiment. Hence we see, that a mixture of sulphate and subcarbonate of potash, in which the proportions of their two acids shall be within the limits pointed out, will have no action either on the sulphate or carbonate of barytes. For the other insoluble salts, there will be other relations of quantity; but there is always a certain interval, more or less considerable, between their limits. The mutual action of sulphate of soda and carbonate of barytes is almost instantaneous. It is sufficient to pour a boiling hot solution of the sulphate on the carbonate placed on a filter, in order that more than three-fourths of the sulphuric acid be precipitated, and replaced by a corresponding quantity of carbonic acid.

TABLE OF ELECTIVE ATTRACTIONS, BY DR. YOUNG.

I. *TABLE of the Sequences of the Bases with the different Acids.*

In all mixtures of the aqueous solutions of two salts, each acid remains united to the base which stands nearest to it in this Table.

SULPHURIC ACID.

Barita	Barita	Barita	Barita	Barita	Barita	Potash	Barita	Barita	Lead
Strontia	Strontia	Potash	Potash	Potash	Potash	Soda	Strontia	Potash	Mercury
Lime	Lime	Soda	Soda	Soda	Soda	Barita	Lime	Soda	Iron
(Silver ?)	Potash	Ammonia	Strontia	Strontia	Strontia	Strontia	Potash	Ammonia	Potash
(Mercury ?)	Soda	Strontia	Ammonia	Ammonia (4)	Ammonia (5)	Ammonia (6)	Soda	Strontia	Soda
Potash	(Mercury ?)	Magnesia (3)	Magnesia	Magnesia (4)	Magnesia	Lime	Magnesia ?	Magnesia	Magnesia
Soda	(Iron ?)	Glycina	Glycina	Glycina	Lime	Magnesia	Ammonia	Glycina	
Zinc	Magnesia	Alumina	Alumina	Alumina	Glycina	Glycina	Glycina	Alumina	Lead
Iron	Ammonia (2)	Zirconia	Zirconia	Zirconia	Alumina	Alumina	Alumina	Zirconia	Zinc
Copper	Glycina	Lime	Lime	Lime	Zirconia	Zirconia	Zirconia	Lime ?	Copper
Magnesia	Alumina (2)								
Ammonia (1)	Zirconia								
Glycina	(Copper ?)								
Alumina									
Zirconia									
NITRIC	MURIATIC	PHOSPHORIC	FLUORIC	SULPHUROUS	BORACIC	CARBONIC	(NITROUS)	(PHOSPHOROUS)	(ACETIC)

(1) Ammonia stands above magnesia when cold. (2) A triple salt is formed. (3) Perhaps magnesia ought to stand lower. (4) A compound salt is formed, and when hot, magnesia stands above ammonia. (5) Fourcroy says, that sulphate of strontia is decomposed by borate of ammonia. (6) With heat, ammonia stands below lime and magnesia.

TABLES
OF
SIMPLE ELECTIVE ATTRACTIONS,
FROM BERGMANN.

I.—WATER AND COMBUSTIBLE SUBSTANCES.

IN THE HUMID WAY.

Water.	Sulphur.	Saline Sulphurets.	Alcohol.	Ether.
Potash	Oxygen	Oxygen	Water	Alcohol
Soda	Molybdic oxide and acid	Oxide of gold	Ether	Volatile oils
Ammonia	Oxide of lead	silver	Volatile oils	Water
Diliquescent salts	tin	mercury	Ammonia	Sulphur
Alcohol	silver	arsenic	Fixed alkali	
Carbonate of ammonia	mercury	antimony	Alkaline sulphurets	
Ether	arsenic	bismuth	Sulphur	
Sulphuric acid	antimony	copper	Muriates	
Non-deliquescent salts	iron	tin	Phosphoric acid	
	Potash	lead		
	Soda	nickel		
	Barytes	cobalt		
	Strontian	manganese		
	Lime	iron		
	Magnesia	Other metallic oxides		
	Phosphorus	Carbon		
	Fat oils	Water		
	Ammonia	Alcohol		
	Ether	Ether		
	Hydrogen			

Fat Oils.	Volatile Oils.
Barytes ?	Ether
Strontian ?	Alcohol
Lime	Fat oils
Metallic oxides	Fixed alkalis
Ether	Sulphur
Volatile oils	Phosphorus
Fixed alkalis	
Ammonia	
Sulphur	
Phosphorus	

Sulphuretted Hydrogen.
Barytes
Potash
Soda
Lime
Ammonia
Magnesia
Zircon

IN THE DRY WAY.

Oxygen	Manganese
Potash	Iron
Soda	Copper
Iron	Tin
Copper	Lead
Tin	Silver
Lead	Gold
Silver	Antimony
Cobalt	Cobalt
Nickel	Nickel
Bismuth	Bismuth
Antimony	Mercury
Mercury	Arsenic
Arsenic	Carbon ?
Uranium ?	
Molybdena	
Tellurium	

TABLE OF SIMPLE ELECTIVE ATTRACTIONS.

II.—OXYGEN AND METALS.

IN THE HUMID WAY.

Oxygen.	Oxide of Gold.	Oxide of Silver.	Oxide of Platina.	Oxide of Mercury.	Oxide of Lead.
Zinc	Acids, gallic	Acids, gallic	Acids, gallic	Acids, gallic	Acids, gallic
Iron	muriatic	muriatic	muriatic	muriatic	sulphuric
Tin	nitric	oxalic	nitric	oxalic	mucic
Antimony	sulphuric	sulphuric	sulphuric	succinic	oxalic
Arsenic	arsenic	mucic	arsenic	phosphoric	arsenic
Lead	fluoric	phosphoric	fluoric	sulphuric	tartaric
Bismuth	tartaric	sulphurous	tartaric	mucic	phosphoric
Copper	phosphoric	nitric	phosphoric	tartaric	muriatic
Platinum	acetic	arsenic	oxalic	citric	sulphurous
Mercury	sebacic	fluoric	citric	malic	suberic
Palladium	prussic	tartaric	acetic	sulphurous	nitric
Rhodium	Fixed alkalis	citric	succinic	nitric	fluoric
Iridium	Ammonia	succinic	prussic	fluoric	citric
Osmium	Sulphuretted hydrogen	acetic	carbonic	acetic	malic
Silver		prussic	Ammonia	benzoic	succinic
Gold		carbonic		boracic	acetic
		Ammonia		prussic	benzoic
				carbonic	boracic
				Ammonia	prussic
					carbonic
					Fixed alkalis
					Fat oils
					Ammonia

IN THE DRY WAY.

	Gold.	Silver.	Platina.	Mercury.	Lead.
Titanium	Mercury	Lead	Arsenic	Gold	Gold
Manganese	Copper	Copper	Gold	Silver	Silver
Zinc	Silver	Mercury	Copper	Platina	Copper
Iron	Lead	Bismuth	Tin	Lead	Mercury
Tin	Bismuth	Tin	Bismuth	Tin	Bismuth
Uranium	Tin	Gold	Zinc	Zinc	Tin
Molybdena	Antimony	Antimony	Antimony	Bismuth	Antimony
Tungsten	Iron	Iron	Nickel	Copper	Platina
Cobalt	Platina	Manganese	Cobalt	Antimony	Arsenic
Antimony	Zinc	Zinc	Manganese	Arsenic	Zinc
Nickel	Nickel	Arsenic	Iron	Iron	Nickel
Arsenic	Arsenic	Nickel	Lead	Alkaline sulphurets	Iron
Chromium	Cobalt	Platina	Silver	Sulphur	Alkaline sulphurets
Bismuth	Manganese	Alkaline sulphurets	Mercury		Sulphur
Lead	Alkaline sulphurets		Alkaline sulphurets		
Copper					
Tellurium					
Platinum					
Mercury					
Silver					
Gold					
Hydrogen					
Carbon					
Boron					
Phosphorus					
Sulphur					
Azote					
Chlorine					

The column under oxygen is divided into two parts. The first exhibits the order in which the metals precipitate one another from acid solutions; the second, according to Vauquelin, shows the affinities of the metals for oxygen, represented by the difficulty with which their oxides are decomposed by heat. It is different from Bergmann's column.

TABLE OF SIMPLE ELECTIVE ATTRACTIONS.

METALS—(CONTINUED.)

IN THE HUMID WAY.

Oxide of Copper.	Oxide of Iron.	Oxide of Tin.	Oxide of Bismuth.	Oxide of Nickel.	Oxide of Arsenic.
Acids, gallic	Acids, gallic	Acids, gallic	Acids, oxalic	Acids, oxalic	Acids, gallic
oxalic	oxalic	tartaric	arsenic	muriatic	muriatic
tartaric	tartaric	muriatic	tartaric	sulphuric	oxalic
muriatic	camphoric	sulphuric	phosphoric	tartaric	sulphuric
sulphuric	sulphuric	oxalic	sulphuric	nitric	nitric
mucic	mucic	arsenic	muriatic	sebacic	sebacic
nitric	muriatic	phosphoric	nitric	phosphoric	tartaric
arsenic	nitric	nitric	fluoric	fluoric	phosphoric
phosphoric	phosphoric	succinic	mucic	mucic	fluoric
succinic	arsenic	fluoric	succinic	succinic	mucic
fluoric	fluoric	mucic	citric	citric	succinic
citric	succinic	citric	acetic	acetic	citric
acetic	citric	acetic	arsenic	prussic	arsenic
boracic	acetic	boracic	boracic	carbonic	acetic
prussic	boracic	prussic	prussic	Ammonia	prussic
carbonic	prussic	Potash	carbonic		Fixed alkalis
Potash	carbonic	Soda	Ammonia		Ammonia
Soda		Ammonia			Fat oils
Ammonia					Water
Compound salts					
Fat oils					

IN THE DRY WAY.

Copper.	Iron.	Tin.	Bismuth.	Nickel.	Arsenic.
Gold	Nickel	Zinc	Lead	Iron	Nickel
Silver	Cobalt	Mercury	Silver	Cobalt	Cobalt
Iron	Manganese	Copper	Gold	Arsenic	Copper
Arsenic	Arsenic	Antimony	Mercury	Copper	Iron
Manganese	Copper	Gold	Antimony	Gold	Silver
Zinc	Gold	Silver	Tin	Tin	Tin
Antimony	Silver	Lead	Copper	Antimony	Lead
Platina	Tin	Iron	Platina	Platina	Gold
Tin	Antimony	Manganese	Nickel	Bismuth	Platina
Lead	Platina	Nickel	Iron	Lead	Zinc
Nickel	Bismuth	Arsenic	Zinc	Silver	Antimony
Bismuth	Lead	Platina	Alkaline sulphurets	Zinc	Alkaline sulphurets
Cobalt	Alkaline sulphurets	Bismuth	Sulphur	Alkaline sulphurets	Sulphur
Mercury	Sulphur	Cobalt		Sulphur	
Alkaline sulphurets		Alkaline sulphurets			
Sulphur		Sulphur			

TABLE OF SIMPLE ELECTIVE ATTRACTIONS.

METALS—(CONCLUDED.)

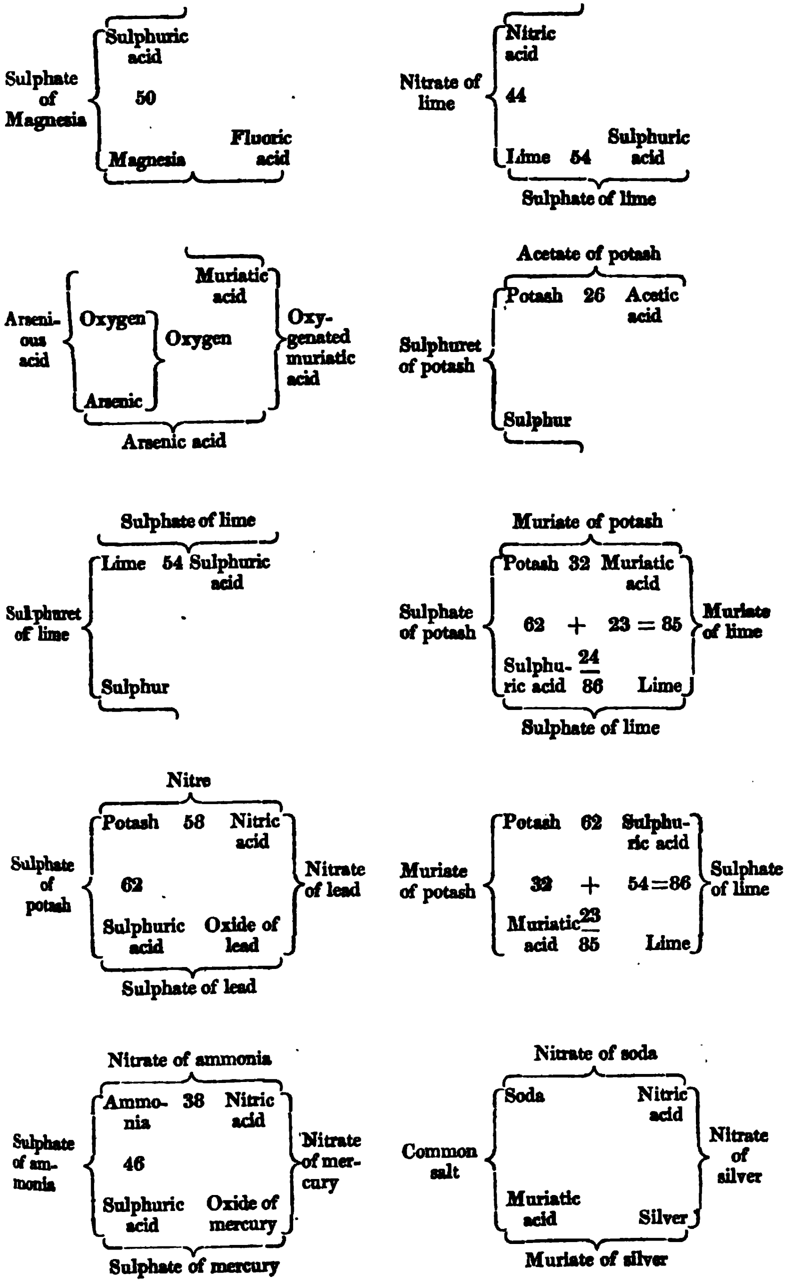
IN THE HUMID WAY.

Oxide of Cobalt.	Oxide of Zinc.	Oxide of Antimony.	Oxide of Manganese.	Oxide of Tellurium.	Oxide of Titanium.	Oxide of Uranium.
Acids, oxalic	Acids, gallic	Acids, gallic	Acids, oxalic	Acids, nitric	Acids, sulphuric	Acids, sulphuric
muriatic	oxalic	muriatic	tartaric	nitro-muriatic	nitric	nitro-muriatic
sulphuric	sulphuric	benzoic	citric	sulphuric	muriatic	muriatic
tartaric	muriatic	oxalic	fluoric	Sulphur	prussic	nitric
nitric	mucic	sulphuric	phosphoric	Alkalis		phosphoric
phosphoric	nitric	nitric	nitric	Mercury		acetic
fluoric	tartaric	tartaric	sulphuric			gallic
mucic	phosphoric	mucic	muriatic			prussic
succinic	citric	phosphoric	arsenic			carbonic
citric	succinic	citric	acetic			Sulphur
acetic	fluoric	succinic	prussic			
arsenic	arsenic	fluoric	carbonic			
boracic	acetic	arsenic				
prussic	boracic	acetic				
carbonic	prussic	boracic				
Ammonia	carbonic	prussic				
	Fixed alkalis	carbonic				
	Ammonia	Sulphur				
		Fixed alkalis				
		Ammonia				

IN THE DRY WAY.

Cobalt.	Zinc.	Antimony.	Manganese.	Tellurium.
Iron	Copper	Iron	Copper	Mercury
Nickel	Antimony	Copper	Iron	Sulphur
Arsenic	Tin	Tin	Gold	
Copper	Mercury	Lead	Silver	
Gold	Silver	Nickel	Tin	
Platina	Gold	Silver	Alkaline sulphurets	
Tin	Cobalt	Bismuth		
Antimony	Arsenic	Zinc		
Zinc	Platina	Gold		
Alkaline sulphurets	Bismuth	Platina		
Sulphur	Lead	Mercury		
	Nickel	Arsenic		
	Iron	Cobalt		
		Alkaline sulphurets		
		Sulphur		

Scheme of Double Affinities in the Humid Way.



AUGITE. Pyroxene of Haüy. This mineral is for the most part crystallized in small six or eight-sided prisms, with dihedral summits. It is found also in grains. Its colours are green, brown, and black. Internal lustre shining. Uneven fracture. Translucent. Easily broken. It scratches glass. Sp. gr. 3.3. Melts into a black enamel. Its composition, according to Klaproth, is 48 silica, 24 lime, 12 oxide of iron, 8.75 magnesia, 5 alumina, 1 manganese. It is met with among volcanic rocks, but is supposed to have existed prior to the eruption and ejection of the lava. Large crystals of it are also found in basalt, of a finer green, and more brilliant than those found in lavas. It occurs with olivin in the basalt of Teesdale; in the trap rocks round Edinburgh; and in several of the Hebrides.

Sahlite and coccolite are considered to be varieties of augite.

AURUM FULMINANS. See Fulminating.

AURUM GRAPHICUM. See Ores of Gold.

AURUM MUSIVUM, or MOSAICUM. A combination of tin and sulphur, which is thus made: Melt twelve ounces of tin, and add to it three ounces of mercury; triturate this amalgam with seven ounces of sulphur, and three of muriate of ammonia. Put the powder into a matrass, bedded rather deep in sand, and keep it for several hours in a gentle heat; which is afterward to be raised, and continued for several hours longer. If the heat have been moderate, and not continued too long, the golden-coloured scaly porous mass, called aurum musivum, will be found at the bottom of the vessel; but if it have been too strong, the aurum musivum fuses to a black mass of a striated texture. This process is thus explained: As the heat increases, the tin, by stronger affinity, seizes and combines with the muriatic acid of the muriate of ammonia; while the alkali of that salt, combining with a portion of the sulphur, flies off in the form of a sulphuret. The combination of tin and muriatic acid sublimes; and is found adhering to the sides of the matrass. The mercury, which served to divide the tin, combines with part of the sulphur, and forms cinnabar, which also sublimes; and the remaining sulphur, with the remaining tin, forms the aurum musivum which occupies the lower part of the vessel. It must be admitted, however, that this explanation does not indicate the reasons why such an indirect and complicated process should be required to form a simple combination of tin and sulphur.

It does not appear that the proportions of the materials require to be strictly attended to. The process of the Marquis de Bullion, as described by Chaptal in his Elements of Chemistry, consists in amalgamating eight ounces of tin with eight ounces of mercury, and mixing this with six ounces of sulphur and four of muriate of ammonia. This mixture is to be exposed for three hours on a sand heat sufficient to render the bottom of the matrass obscurely red-hot. But Chaptal himself found that if the matrass containing the mixture were exposed to a naked fire, and violently heated, the mixture took fire, and a sublimate was formed in the neck of the matrass, consisting of the most beautiful aurum musivum in large hexagonal plates.

Aurum musivum has no taste, though some specimens exhibit a sulphureous smell. It is not soluble in water, acids, or alkaline solutions. But in the dry way it forms a yellow sulphuret, soluble in water. It deflagrates with nitre. Bergman mentions a native aurum musivum from Siberia, containing tin, sulphur, and a small proportion of copper.

Aurum musivum is used as a pigment for giving a golden colour to small statue or plaster figures. It is likewise said to be mixed with melted glass to imitate lapis lazuli.

Mosaic gold is composed of 100 tin + 56.25 sulphur, by Dr. John Davy; and of 100 tin + 52.3 sulphur, by Professor Berzelius; the mean of which, or 100 + 54.2 is probably correct. It will then consist of 1 prime of tin = 7.375 + 2 sulphur = 4.0.

AVANTURINE. A variety of quartz rock containing mica spangles. The most beautiful comes from Spain, but Dr. M'Culloch found specimens at Glen Fernat in Scotland, which, when polished, were equal in beauty to any of the foreign. The most usual colour of the base of avanturine is brown, or reddish-brown, enclosing golden-coloured spangles.

AUTOMALITE. This mineral occurs in regular octohedrons, and tetrahedrons. It scratches glass. Sp. gr. 4.26 — 4.69. It is nearly opaque, the light transmitted being of a dark bluish-green colour. It is composed of alumina 42; silica 4; oxide of zinc 28; oxide of iron 5; sulphur 17. *Vauquelin.* It is found in a talcose rock at Fahlun in Sweden, and is sometimes called Fahlunite. *Philips' Mineralogy.*

AXE-STONE. A subspecies of jade, from which it differs in not being of so light a green, and in having a somewhat slaty texture. The natives of New Zealand work it into hatchets. It is found in Corsica, Switzerland, Saxony, and on the banks of the river Amazon, whence it has been called Amazonian stone. Its constituents are silica 50.5, magnesia 31, alumina 10, oxide of iron 5.5, water 2.75, oxide of chromium 0.05.

AXINITE, or THUMERSTONE. This mineral is sometimes massive, but most usually crystallized. The crystals resemble an axe in the form and sharpness of their edges; being flat rhomboidal parallelopipeds, with two of the opposite edges wanting, and a small face instead of each. They are translucent, and of a violet colour, whence called violet schorl. They become electric by heat. The usual colour is clove-brown. Lustre splendent. Hard, but yields to the file, and easily broken. Sp. gr. 3.25. It froths like zeolite before the blowpipe, melting into a black enamel, or a dark green glass. According to Vauquelin's analysis, it contains 44 silica, 18 alumina, 19 lime, 14 oxide of iron, and 4 oxide of manganese. It is found in beds at Thum in Saxony; in Killas at Botallack near the Land's-end, Cornwall; and at Trewellard in that neighbourhood.

AZOTANE, chloride of azote. See NITROGEN.

AZOTE. See GAS (NITROGEN).

AZURE-STONE, or LAPIS LAZULI. This massive mineral is of a fine azure-blue colour. Lustre glistening. Fine grained uneven fracture. Scratches glass, but scarcely strikes fire with steel. Opaque, or translucent on the very edges. Easily broken. Sp. grav. 2.85. In a very strong heat it intumesces, and melts into a yellowish black mass. After calcination it forms a jelly with acids. It consists of 46 silica, 28 lime, 14.5 alumina, 3 oxide of iron, 6.5 sulphate of lime, and 2 water, according to Klaproth. But by a later and most interesting research of MM. Clement and Desormes, lapis lazuli appears to be composed of 34 silica, 33 alumina, 3 sulphur, and 22 soda. (Ann. de Chimie, tom. 57.) In this analysis, however, a loss of eight per cent. was experienced. These distinguished chemists consider the above ingredients essential, and the 2.4 of lime and 1.5 of iron, which they have occasionally met with, as accidental. It is from azure stone that the beautiful and unchangeable blue colour ultramarine is prepared. The finest specimens are brought from China, Persia, and Great Bucharia. They are made red-hot in the fire, and thrown into water to render them easily pulverizable. They are then reduced to a fine powder, and intimately combined with a varnish, formed of resin, wax, and boiled linseed oil. This pasty mixture is put into a linen cloth, and repeatedly kneaded with hot water: the first water, which is usually dirty, is thrown away; the second gives a blue of the first quality; and the third yields one of less value. The process is founded on the property which the colouring matter of azure-stone has of adhering less firmly to the resinous cement than the foreign matter with which it is associated.

When azure stone has its colour altered by a moderate heat, it is reckoned bad. MM. Clement and Desormes consider the extraction of ultramarine as a species of saponification.

AZURITE, or PRISMATIC AZURE SPAR, the LAZULITE of Werner and Haüy. This mineral is often found in oblique quadrangular crystals of a fine blue colour. It is translucent only on the edges, brittle, and nearly as hard as quartz. When massive, it is either in grains, or bits like a hazel nut. It occurs imbedded in mica slate. Its lustre is vitreous. Its constituents are 66 alumina, 18 magnesia, 10 silica, 2.5 oxide of iron, 2 lime. It occurs in Vorau in Stiria, in a gangue of quartz; but the finest specimens come from the bishopric of Salzburg.

B

BABINGTONITE. A new mineral, in small brilliant crystals, associated with cleavlandite, flesh-coloured felspar, and green amphibole, on a specimen from Arendal. *M. Levy in Annals of Phil.* vii. 275.

BAIKALITE. See TREMOLITE ASBESTIFORM.

BALANCE. The beginning and end of every exact chemical process consists in weighing. With imperfect instruments this operation will be tedious and inaccurate; but with a good balance, the result will be satisfactory; and much time, which is so precious in experimental researches, will be saved.

The balance is a lever, the axis of motion of which is formed with an edge like that of a knife; and the two dishes at its extremities are hung upon edges of the same kind. These edges are first made sharp, and then rounded with a fine hone, or a piece of buff leather. The excellence of the instrument depends, in a great measure, on the regular form of this rounded part. When the lever is considered as a mere line, the two outer edges are called points of suspension, and the inner the fulcrum. The points of suspension are supposed to be at equal distances from the fulcrum, and to be pressed with equal weights when loaded.

1. If the fulcrum be placed in the centre of gravity of the beam, and the three edges lie all in the same right line, the balance will have no tendency to one position more than another, but will rest in any position it may be placed in, whether the scales be on or off, empty or loaded.

2. If the centre of gravity of the beam, when level, be immediately above the fulcrum, it will overset by the smallest action; that is, the end which is lowest will descend: and it will do this with more swiftness, the higher the centre of gravity, and the less the points of suspension are loaded.

3. But if the centre of gravity of the beam be immediately below the fulcrum, the beam will not rest in any position but when level;

and, if disturbed from this position, and then left at liberty, it will vibrate, and at last come to rest on the level. Its vibrations will be quicker, and its horizontal tendency stronger, the lower the centre of gravity, and the less the weights upon the points of suspension.

4. If the fulcrum be below the line joining the points of suspension, and these be loaded, the beam will overset, unless prevented by the weight of the beam tending to produce a horizontal position, as in § 3. In this last case, small weights will equilibrate, as in § 3.; a certain exact weight will rest in any position of the beam, as in § 1.; and all greater weights will cause the beam to overset, as in § 2. Many scales are often made this way, and will overset with any considerable load.

5. If the fulcrum be above the line joining the points of suspension, the beam will come to the horizontal position, unless prevented by its own weight, as in § 2. If the centre of gravity of the beam be nearly in the fulcrum, all the vibrations of the loaded beam will be made in times nearly equal, unless the weights be very small, when they will be slower. The vibrations of balances are quicker, and the horizontal tendency stronger, the higher the fulcrum.

6. If the arms of a balance be unequal, the weights in equipoise will be unequal in the same proportion. It is a severe check upon a workman to keep the arms equal, while he is making the other adjustments in a strong and inflexible beam.

7. The equality of the arms of a balance is of use, in scientific pursuits, chiefly in making weights by bisection. A balance with unequal arms will weigh as accurately as another of the same workmanship with equal arms, provided the standard weight itself be first counterpoised, then taken out of the scale, and the thing to be weighed be put into the scale and adjusted against the counterpoise; or when proportional quantities only are considered, as in chemical and in other philosophical experiments, the bodies and products under examination may be weighed against the weights, taking care always to put the weights into the same scale. For then, though the bodies may not be really equal to the weights, yet their proportions among each other may be the same as if they had been accurately so.

8. But though the equality of the arms may be well dispensed with, yet it is indispensably necessary that their relative lengths, whatever they may be, should continue invariable. For this purpose, it is necessary, either that the three edges be all truly parallel, or that the points of suspension and support should be always in the same part of the edge. This last requisite is the most easily obtained.

The balances made in London are usually constructed in such a manner, that the bearing parts form notches in the other parts of the edges; so that the scales being set to vibrate, all the parts naturally fall into the same bearing. The balances made in the country have the fulcrum edge straight, and confined to one constant bearing by two side plates. But the points of suspension are referred to notches in the edges, like the London balances. The balances here mentioned, which come from the country, are enclosed in a small iron japanned box; and are to be met with at Birmingham and Sheffield warehouses, though less frequently than some years ago; because a pocket contrivance for weighing guineas and half-guineas has got possession of the market. They are, in general, well made and adjusted, turn with the twentieth of a grain when empty, and will sensibly show the tenth of a grain, with an ounce in each scale. Their price is from five shillings to half a guinea; but those which are under seven shillings have not their edges hardened, and consequently are not durable. This may be ascertained by the purchaser, by passing the point of a penknife across the small piece which goes through one of the end boxes: if it makes any mark or impression, the part is soft.

9. If a beam be adjusted so as to have no tendency to any one position, as in § 1. and the scales be equally loaded; then, if a small weight be added in one of the scales, that balance will turn, and the points of suspension will move with an accelerated motion, similar to that of falling bodies, but as much slower, in proportion, very nearly, as the added weight is less than the whole weight borne by the fulcrum.

10. The stronger the tendency to a horizontal position in any balance, or the quicker its vibrations, §§ 3. 5. the greater additional weight will be required to cause it to turn, or incline to any given angle. No balance, therefore, can turn so quick as the motion deduced in § 9. Such a balance as is there described, if it were to turn with the ten-thousandth part of the weight, would move at quickest ten thousand times slower than falling bodies; that is, the dish containing the weight, instead of falling through sixteen feet in a second of time, would fall through only two hundred parts of an inch, and it would require four seconds to move through one-third part of an inch; consequently all accurate weighing must be slow. If the indices of two balances be of equal lengths, that index which is connected with the shorter balance will move proportionally quicker than the other. Long beams are the most in request, because they are thought to have less friction: this is doubtful; but the quicker angular motion, greater strength, and less weight of a short balance, are certainly advantages.

11. Very delicate balances are not only useful in nice experiments, but are likewise much more expeditious than others in common weighing. If a pair of scales with a certain

load be barely sensible to one-tenth of a grain, it will require a considerable time to ascertain the weight to that degree of accuracy, because the turn must be observed several times over, and is very small. But if no greater accuracy were required, and scales were used which would turn with the hundredth of a grain, a tenth of a grain, more or less, would make so great a difference in the turn, that it would be seen immediately.

12. If a balance be found to turn with a certain addition, and is not moved by any smaller weight, a greater sensibility may be given to that balance, by producing a tremulous motion in its parts. Thus, if the edge of a blunt saw, a file, or other similar instrument, be drawn along any part of the case or support of a balance, it will produce a jarring, which will diminish the friction on the moving parts so much, that the turn will be evident with one-third or one-fourth of the addition that would else have been required. In this way, a beam which would barely turn by the addition of one-tenth of a grain, will turn with one-thirtieth or fortieth of a grain.

13. A balance, the horizontal tendency of which depends only on its own weight, as in § 3. will turn with the same addition, whatever may be the load; except so far as a greater load will produce a greater friction.

14. But a balance, the horizontal tendency of which depends only on the elevation of the fulcrum, as in § 5. will be less sensible the greater the load; and the addition requisite to produce an equal turn will be in proportion to the load itself.

15. In order to regulate the horizontal tendency in some beams, the fulcrum is placed below the points of suspension, as in § 4. and a sliding weight is put upon the cock or index, by means of which the centre of gravity may be raised or depressed. This is an useful contrivance.

16. Weights are made by a subdivision of a standard weight. If the weight be continually halved, it will produce the common pile, which is the smallest number for weighing between its extremes, without placing any weight in the scale with the body under examination. Granulated lead is a very convenient substance to be used in this operation of halving, which, however, is very tedious. The readiest way to subdivide small weights consists in weighing a certain quantity of small wire, and afterward cutting it into such parts, by measure, as are desired: or the wire may be wrapped close round two pins, and then cut asunder with a knife. By this means it will be divided into a great number of equal lengths, or small rings. The wire ought to be so thin, as that one of these rings may barely produce a sensible effect on the beam. If any quantity (as, for example, a grain) of these rings be weighed, and the number then reckoned, the grain may be subdivided in any proportion, by dividing that number, and making the weights equal to as many of the rings as the quotient of the division denotes. Then, if 750 of the rings amounted to a grain, and it were required to divide the grain decimally, downwards, 9-10ths would be equal to 675 rings, 8-10ths would be equal to 600 rings, 7-10ths to 525 rings, &c. Small weights may be made of thin leaf brass. Jewellers' foil is a good material for weights below 1-10th of a grain, as low as to 1-100th of a grain; and all lower quantities may be either estimated by the position of the index, or shown by actually counting the rings of wire, the value of which has been determined.

17. In philosophical experiments, it will be found very convenient to admit no more than one dimension of weight. The grain is of that magnitude as to deserve the preference. With regard to the number of weights the chemists ought to be provided with, writers have differed according to their habits and views. Mathematicians have computed the least possible number, with which all weights within certain limits might be ascertained; but their determination is of little use. Because, with so small a number, it must often happen, that the scales will be heavily loaded with weights on each side, put in with a view only to determine the difference between them. It is not the least possible number of weights which it is necessary an operator should buy to effect his purpose, that we ought to inquire after, but the most convenient number for ascertaining his inquiries with accuracy and expedition. The error of adjustment is the least possible, when only one weight is in the scale; that is, a single weight of five grains is twice as likely to be true, as two weights, one of three, and the other of two grains, put into the dish to supply the place of the single five; because each of these last has its own probability of error in adjustment. But since it is as inconsistent with convenience to provide a single weight, as it would be to have a single character for every number; and as we have nine characters, which we use in rotation, to express higher values according to their position, it will be found very serviceable to make the set of weights correspond with our numerical system. This directs us to the set of weights as follows: 1000 grains, 900 g. 800 g. 700 g. 600 g. 500 g. 400 g. 300 g. 200 g. 100 g. 90 g. 80 g. 70 g. 60 g. 50 g. 40 g. 30 g. 20 g. 10 g. 9 g. 8 g. 7 g. 6 g. 5 g. 4 g. 3 g. 2 g. 1 g. $\frac{9}{10}$ g. $\frac{8}{10}$ g. $\frac{7}{10}$ g. $\frac{6}{10}$ g. $\frac{5}{10}$ g. $\frac{4}{10}$ g. $\frac{3}{10}$ g. $\frac{2}{10}$ g. $\frac{1}{10}$ g. $\frac{9}{100}$ g. $\frac{8}{100}$ g. $\frac{7}{100}$ g. $\frac{6}{100}$ g. $\frac{5}{100}$ g. $\frac{4}{100}$ g. $\frac{3}{100}$ g. $\frac{2}{100}$ g. $\frac{1}{100}$ g. With these the philosopher will always have the same number of weights in his scales as there are figures in the number expressing the weights in grains.

Thus 742.5 grains will be weighed by the weights 700, 40, 2, and 5-10ths.

A balance (made by Ramsden, and turning on points instead of edges) in the possession of Dr. George Fordyce, is mentioned in the seventy-fifth volume of the Philosophical Transactions. With a load of four or five ounces, a difference of one division in the index was made by $\frac{1}{1000}$ of a grain. This is $\frac{1}{384000}$ part of the weight, and consequently this beam will ascertain such weights to five places of figures, beside an estimate figure.

The Royal Society's balance, which was lately made by Ramsden, turns on steel edges, upon planes of polished crystal. It is said to ascertain a weight to the seven-millionth part, and it may be used in general practice to determine weights to five places and better.

From this account of balances, the student may form a proper estimate of the value of those tables of specific gravities, which are carried to five, six, and even seven places of figures, and likewise of the theoretical deductions in chemistry, that depend on a supposed accuracy in weighing, which practice does not authorise. In general, where weights are given to five places of figures, the last figure is an estimate, or guess figure; and where they are carried farther, it may be taken for granted, that the author deceives either intentionally, or from want of skill in reducing his weights to fractional expressions, or otherwise.

The most exact standard weights were procured, by means of the ambassadors of France, resident in various places; and these were compared by Mons. Tillet with the standard mark in the pile preserved in the Cour de Monnoies de Paris. His experiments were made with an exact balance made to weigh one marc, and sensible to one quarter of a grain. Now, as the marc contains 18432 quarter grains, it follows that this balance was a good one, and would exhibit proportions to four places, and a guess figure. The results are contained in the following table, extracted from Mons. Tillet's excellent paper in the Memoirs of the Royal Academy of Sciences for the year 1767. I have added the two last columns, which show the number of French and English grains contained in the compound quantities against which they stand. The English grains are computed to one-tenth of a grain, although the accuracy of weighing came no nearer than about two-tenths.

The weights of the kilogramme, gramme, decigramme, and centigramme, which are now frequently occurring in the French chemical writers, are added at the bottom of this table according to their respective values.

Table of the Weights of different Countries.

Place and Denomination of Weights.	Marc.	oz.	gros.	grains.	F. grains.	E. grains.
Berlin. The marc of 16 loths, . .	—	7	5	16	4408	3616.3
Berne. Goldsmiths' weight of 8 ounces,	1	—	½	4	4648	3813.2
Berne. Pound of 16 ounces for merchandise, ...	2	1	½	6	9834	8067.7
The common pound varies very considerably in other towns of the canton.						
Berne. Apothecaries' weight of 8 ounces,	—	7	5½	26	4454	3654.
Bonn, ...	—	7	5	6	4398¾	3608.6
Brussels. The marc, or original troyes weight, ...	1	—	—	21	4629	3797.6
Cologn. The marc of 16 loths, . .	—	7	5	11	4403	3612.2
Constantinople. The cheki, or 100 drachms,	1	2	3	28	6004	4925.6
Copenhagen. Goldsmiths' weight commonly supposed equal to the marc of Cologn,	—	7	5½	10⅓	4438⅓	3641.2
Copenhagen. Merchants' weight of 16 loths,	1	—	1	22½	4702½	3857.9
Dantzic weight; commonly supposed equal to the marc of Cologn, . . .	—	7	5	3½	4395½	3606.
Florence. The pound (anciently used by the Romans), ...	1	3	½	20	6392	5 44.
Genoa. The peso sotile, . . .	1	2	2½	30	5970	4897.7
Genoa. The peso grosso, ...	1	2	3	5	5981	4906.7
Hamburgh weight; commonly supposed equal to the Cologn marc, . .	—	7	5	7¾	4399¾	3609.4
Hamburgh. Another weight, . .	—	7	7	23	4559	3740.2
Liege. The Brussels marc used; but the weight proved, ...	1	—	—	24	4632	3800.1
Lisbon. The marc, or half pound, . .	—	7	3½	34	4318	3542.4
London. The pound troy, . . .	1	4	1½	1	7021	5760.
London. The pound avoirdupois, . .	1	6	6⅔	6	8538	7004.5
Lucca. The pound, ...	1	3	—	23	6359¼	5217.
Madrid. The marc royal of Castile, .	—	7	4	8¼	4328	3550.7

Place and Denomination of Weights.	Marc.	oz.	gros.	grains	F. grains.	E grains.
Malta. The pound,	1	2	2½	21	5961	4890.4
Manheim. (The Cologn marc,)	—	7	5	10	4402	3611.5
Milan. The marc,	—	7	5	33¼	4425	3660.2
Milan. The libra grossa,	3	—	7½	—	14364½	11784.
Munich. (The Cologn marc,)	—	7	5	11	4403½	3612.3
Naples. The pound of 12 ounces,	1	2	3½	27½	6039	4954.3
Ratisbon. The weight for gold of 128 crowns,	1	6	—	24	8088	6635.3
Ratisbon. The weight for ducats: of 64 ducats,	—	7	2	32	4208	3452.3
Ratisbon. The marc of 8 ounces,	1	—	—	24	4632	3800.1
Ratisbon. The pound of 16 ounces,	2	2	4½	6	10698	8776.5
Rome. The pound of 12 ounces,	1	3	½	14	6386	5239.
Stockholm. The pound of 2 marcs,	1	5	7	8	8000	6563.1
Stuttgard. (The Cologn marc,)	—	7	5	11¾	4403¼	3612.6
Turin. The marc of 8 ounces,	—	—	—	22¼	4630⅔	3799.
At Turin they have also a pound of 12 of the above ounces. But, in their apothecaries' pound of 12 ounces, the ounce is one-sixth lighter.						
Warsaw. The pound,	1	5	2	12	7644	6271.
Venice. The libra grossa of 12 ounces,	1	7	4½	25½	8989½	7374.5
Venice. The peso sottile of 12 ounces,	1	1	6½	24	5676	4656.5
In the bounds dependent on Venice, the pound differs considerably in each.						
Vienna. The marc of commerce,	1	1	1	16	5272	4325.
Vienna. The marc of money,	1	1	1	26	5282	1433.3
England. The grain,	—	—	—	—	0.82039	1.
France. The grain,	—	—	—	—	1.	1.21895
The kilogramme,	4	—	5	35	18827.15	15445.5
The gramme,	—	—	—	—	18.827	15.445
The decigramme,	—	—	—	—	1.8827	1.5445
The centigramme,	—	—	—	—	.18827	.15445

See TABLE of WEIGHTS and MEASURES in the Appendix.

The commissioners appointed by the British Government for considering the subject of weights and measures, gave in their first report on the 24th June, 1819. The following is the substance of it.

"1. With respect to the actual magnitude of the standards of length, the commissioners are of opinion, that there is no sufficient reason for altering those generally employed, as there is no practical advantage in having a quantity commensurable to any original quantity existing, or which may be imagined to exist, in nature, except as affording some little encouragement to its common adoption by neighbouring nations.

"2. The subdivisions of weights and measures at present employed in this country appear to be far more convenient for practical purposes than the decimal scale. The power of expressing a third, a fourth, and a sixth of a foot in inches, without a fraction, is a peculiar advantage in the duodecimal scale; and for the operation of weighing and of measuring capacities, the continual division by two renders it practicable to make up any given quantity with the smallest possible number of weights and measures, and is far preferable in this respect to any decimal scale. The commissioners therefore recommend, that all the multiples and subdivisions of the standard to be adopted should retain the same relative proportions to each other as are at present in general use.

"3. That the standard yard should be that employed by General Roy in the measurement of a base on Hounslow Heath, as a foundation of the great trigonometrical survey.

"4. That in case this standard should be lost or impaired, it shall be declared that the length of a pendulum, vibrating seconds of mean solar time in London, on the level of the sea, and in a vacuum, is 39.1372 inches of the standard scale, and that the length of the French metre, as the 10-millionth part of the quadrantal arc of the meridian, has been found equal to 39.3694 inches.

"5. That 10 ounces troy, or 4800 grains, should be declared equal to the weight of 19 cubic inches of distilled water, at the temperature of 50°, and that one pound avoirdupois must contain 7000 of these grains.

"6. That the standard ale and corn gallon should contain exactly *ten* pounds avoirdupois of distilled water at 62° Fahr. being nearly equal to 277.3 cubic inches, and agreeing with the standard pint in the Exchequer, which is found to contain exactly 20 ounces of water. The customary ale gallon contains 282 cubic inches, and the Winchester corn gallon 269, or according to other statutes 272¼ cubic inches; so that no inconvenience can possibly be felt from the introduction of a new gallon of 277.3 inches. The commissioners have not decided upon the propriety of abolishing entirely the use of the wine gallon."

The following simple relations of weight and measure were suggested by Dr. Wollaston, in his examination before the committee; and they have been adopted in the national system:—

"There is one standard of capacity that would be *particularly* advantageous, because it would bear simple proportions to the measures now in use, so that one of the great inconveniencies arising from change of the standard would be obviated, by the facility of making many necessary computations without reference to tables.

"If the gallon measure be defined to be that which contains 10lbs. of water at 56½° F.; then, since the cubic foot of water weighs 1000 oz. at 56½°,

½ pint = 18 oz. = $\frac{1}{100}$
Pint = 20 oz. = 34.56 cubic foot = 17.28 inches.
Bushel = 80 lb. = 2211.84 inches.

And the simple proportions above alluded to will be found as follows:

	Cubic Inches.			
The gallon of 10 lb.	= 276.48	× $\frac{49}{48}$	= 282.01	282 beer gallon.
Also,	= 276.48	× $\frac{10}{12}$	= 230.40	231 wine gallon.
The pint of 1¼ lb.	= 34.56	× 3	= 103.68	103 4 Stirlg. jug.
Bushel of 80 lb.	= 2211.84	× $\frac{35}{36}$	= 2150.40	2150.42 Winch. bush.
A cylinder of 18¾ in diam.		× 8	= 2208.93	Approximate bush.
Ditto 18¾		× 8.0105		221.184 new bush.

"The following mode of defining the standards of length, weight, and capacity, is submitted to the committee on weights and measures, as the most distinct answer to their inquiries:—

One yard of 36 inches, } *is* such, that a pendulum of 39.13 inches, vibrates seconds in London.

Avoir. { one pound, of 16 oz. } *is* such, that one cubic foot of water at 56½°, weighs 1000 oz.

Troy, { one pound, of 5760 grains, } *is* such, that 7000 grains = 1 pound (avoirdupois).

One gallon, of 8 pints, } *may be* such as to contain 10 pounds of distilled water at the temperature of 56½° Fahr. with great convenience."

The cubic inch of distilled water at 62°, weighed in air under the common circumstances with brass weights, is equal to 252.456 English grains; and the cubic decimeter, or actual standard chiliogramme is equal to 15433 English grains. See APPENDIX, TABLE ix.

Captain Kater has lately made a small correction on his first determination of the length of the pendulum vibrating seconds in the latitude of London. Instead of 39.13860 inches, as given in the Phil. Trans. for 1818, he has made it 39.13929 inches of Sir Geo. Shuckburgh's standard scale. Mr. Watts, in the 5th number of the Edinburgh Philosophical Journal, makes it = 39.138666 of the above scale, or = 39.1372405 of General Roy's scale, at Captain Kater's temperature of 62° Fahr. and 0.9941 of a metre.

BALAS, or BALAIS RUBY. See SPINELLE.

BALLOON. Receivers of a spherical form are called balloons.

BALLOON. See AEROSTATICS.

BALSAMS, are vegetable juices, either liquid, or which spontaneously become concrete, consisting of a substance of a resinous nature, combined with benzoic acid, or which are capable of affording benzoic acid, by being heated alone, or with water. They are insoluble in water, but readily dissolve in alcohol and ether. The liquid balsams are copaiva, opo-balsam, Peru, styrax, Tolu; the concrete are benzoin, dragon's blood, and storax; which see.

BALSAM OF SULPHUR. A solution of sulphur in oil.

BALDWIN'S PHOSPHORUS. Ignited nitrate of lime.

BARIUM. The metallic basis of the earth barytes has been called barium by its discoverer, Sir H. Davy. Take pure barytes, make it into a paste with water, and put this on a plate of platinum. Make a cavity in the middle of the barytes, into which a globule of mercury is to be placed. Touch the globule with the negative wire, and the platinum with the positive wire of a voltaic battery of about 100 pairs of plates in good action. In a short time an amalgam will be formed, consisting of mercury and barium. This amalgam must be introduced into a little bent tube, made of glass free from *lead*, sealed at one end, which being filled with the vapour of naphtha, is then to be hermetically sealed at the other end. Heat must be applied to the recurved end of the tube, where the amalgam lies. The mercury will distil over, while the barium will remain.

This metal is of a dark grey colour, with a lustre inferior to that of cast-iron. It is fusible at a red heat. Its density is superior to that of sulphuric acid; for though surrounded with globules of gas, it sinks immediately in that liquid. When exposed to air, it instantly becomes covered with a crust of barytes; and when gently heated in air, burns with a deep red light. It effervesces violently in water, converting this liquid into a solution of barytes. Sir H. Davy thinks it probable that barium may be procured by chemical as well as electrical decomposition. When chloride of barium, or even the dry earth, ignited to whiteness, is exposed to the vapour of potassium, a dark grey substance is found diffused through the barytes or the chloride, not volatile, which effervesces copiously in water, and possesses a metallic appearance, which disappears in the air. The potassium, by being thus transmitted, is converted into potash. From indirect experiments Sir H. Davy was inclined to consider barytes as composed of 89.7 barium + 10.3 oxygen = 100. This would make the prime equivalent of barium 8.7, and that of barytes 9.7, compared to that of oxygen 1.0; a determination nearly exact. Dr. Clarke of Cambridge, by exposing dry nitrate of barytes on charcoal, to the intense heat of the condensed hydroxygen flame, observed metallic-looking globules in the midst of the boiling fluid, and the charcoal was found to be studded over with innumerable globules of the most brilliant lustre and whiteness. On letting these globules fall from the charcoal into water, hydrogen was evolved in a continued stream. When the globules are plunged in naphtha, they retain their brilliancy but for a few days.

Barium combines with oxygen in two proportions, forming, 1st, barytes, and 2d, the deutoxide of barium.

Pure barytes is best obtained by igniting, in a covered crucible, the pure crystallized nitrate of barytes. It is procured in the state of hydrate, by adding caustic potash or soda to a solution of the muriate or nitrate. And barytes, slightly coloured with charcoal, may be obtained by strongly igniting the carbonate and charcoal mixed together in fine powder Barytes obtained from the ignited nitrate is of a whitish-grey colour; more caustic than strontites, or perhaps even lime. It renders the syrup of violets green, and the infusion of turmeric red. Its specific gravity by Fourcroy is 4. When water in small quantity is poured on the dry earth, it slakes like quicklime, but perhaps with evolution of more heat. When swallowed it acts as a violent poison. It is destitute of smell.

When pure barytes is exposed, in a porcelain tube, at a heat verging on ignition, to a stream of dry oxygen gas, it absorbs the gas rapidly, and passes to the state of deutoxide of barium. But when it is calcined in contact with atmospheric air, we obtain at first this deutoxide and carbonate of barytes; the former of which passes very slowly into the latter, by absorption of carbonic acid from the atmosphere.

The deutoxide of barium is of a greenish-grey colour, it is caustic, renders the syrup of violets green, and is not decomposable by heat or light. The voltaic pile reduces it. Exposed at a moderate heat to carbonic acid, it absorbs it, emitting oxygen, and becoming carbonate of barytes. The deutoxide is probably decomposed by sulphuretted hydrogen at ordinary temperatures. Aided by heat, almost all combustible bodies, as well as many metals, decompose it. The action of hydrogen is accompanied with remarkable phenomena. At about 392° F. the absorption of this gas commences; but at a heat approaching to redness it is exceedingly rapid, attended with luminous jets proceeding from the surface of the deutoxide. Although much water be formed, none of it appears on the sides of the vessel. It is all retained in combination with the protoxide, which in consequence becomes a hydrate, and thus acquires the property of fusing easily. By heating a certain quantity of barytes with an excess of oxygen in a small curved tube standing over mercury, M. Thenard ascertained, that in the deutoxide the quantity of the oxygen is the double of that in the protoxide. Hence the former will consist of 8.75 barium + 2 oxygen = 10.75 for its prime equivalent. From the facility with which the protoxide passes into the deutoxide, we may conceive that the former may frequently contain a proportion of the latter, to which cause may be ascribed in some degree the discrepancies among chemists, in estimating the equivalent of barytes.

Water at 50° F. dissolves one-twentieth of its weight of barytes, and at 212° about one-half of its weight; though M. Thenard, in a table, has stated it at only one-tenth. As the solution cools, hexagonal prisms, terminated at each extremity with a four-sided pyramid, form. These crystals are often attached to one another, so as to imitate the leaves of fern. Sometimes they are deposited in cubes. They contain about 53 per cent. of water, or 20 prime proportions. The supernatant liquid is barytes water, it is colourless, acrid, and caustic. It acts powerfully on the vegetable purples and yellows. Exposed to the air, it attracts carbonic acid, and the dissolved barytes is converted into carbonate, which falls down in insoluble crusts. It appears from the experiments of M. Berthollet, that heat alone cannot deprive the crystallized hydrate of its water. After exposure to a red heat, when it fuses like potash, a proportion of water remains in combination. This quantity is a prime equivalent = 1.125, to 9.75 of barytes.—— The ignited hydrate is a solid of a whitish-grey colour, caustic, and very dense. It fuses at a heat a little under a cherry-red; is fixed in the fire; attracts, but slowly, carbonic acid from the atmosphere. It yields carburetted hydrogen and carbonate of barytes when heated along with charcoal, provided this be not in excess.

Sulphur combines with barium, when barytes and sulphur are heated together in a crucible. The same compound is more economically obtained by igniting a mixture of sulphate of barytes and charcoal in fine powder. This sulphuret is of a reddish-yellow colour, and when dry without smell. When this substance is put into hot water, a powerful action is manifested. The water is decomposed, and two new products are formed, namely, hydrosulphuret, and hydroguretted sulphuret of barytes. The first crystallizes as the liquid cools, the second remains dissolved. The hydrosulphuret is a compound of 9.75 of barytes with 2.125 sulphuretted hydrogen. Its crystals should be quickly separated by filtration, and dried by pressure between the folds of porous paper. They are white scales, have a silky lustre, are soluble in water, and yield a solution having a greenish tinge. Its taste is acrid, sulphurous, and when mixed with the hydroguretted sulphuret, eminently corrosive. It rapidly attracts oxygen from the atmosphere, and is converted into the sulphate of barytes. The hydroguretted sulphuret is a compound of 9.75 barytes with 4.125 bisulphuretted hydrogen: but contaminated with sulphite and hyposulphite in unknown proportions. The dry sulphuret consists probably of 2 sulphur + 8.75 barium. The readiest way of obtaining barytes water is to boil the solution of the sulphuret with deutoxide of copper, which seizes the sulphur, while the hydrogen flies off, and the barytes remains dissolved.

Phosphuret of barytes may be easily formed by exposing the constituents together to heat in a glass tube. Their reciprocal action is so intense as to cause ignition. Like phosphuret of lime, it decomposes water, and causes the disengagement of phosphuretted hydrogen gas, which spontaneously inflames with contact of air. When sulphur is made to act on the deutoxide of barytes, sulphuric acid is formed, which unites to a portion of the earth into a sulphate.

The salts of barytes are white, and more or less transparent. All the soluble sulphates cause in the soluble salts of barytes a precipitate insoluble in nitric acid. They are all poisonous except the sulphate; and hence the proper counter-poison is dilute sulphuric acid for the carbonate, and sulphate of soda for the soluble salts of barytes. An account has been given of the most useful of these salts under the respective acids. What remains of any consequence will be found in the table of SALTS. For some interesting facts on the decomposition of the sulphate and carbonate, see ATTRACTION. When the object is merely to procure barytes or the sulphuret, form the powdered carbonate or sulphate into a paste with lamp black and coal tar, and subject to strong ignition in a covered crucible. As barytes and strontites are occasionally associated, it becomes an important problem to separate these two earths, which M. Berzelius operates on the following principle. Fluate of silica and barytes precipitates in crystals almost insoluble. The fluate of silica and strontites is very soluble in excess of the fluo-silicic acid. The mixture of the two earths is to be dissolved in muriatic or acetic acid, then solution of fluo-silicic acid is to be poured in, the barytes will precipitate, and its weight is to be determined by that of the precipitate. A very small quantity of sulphuric acid being added to the solution throws down from it the small quantity of barytes that may remain, without acting on the strontites. The liquid is to be filtered, evaporated to dryness, and the residuum decomposed by sulphuric acid. The fluate of silica and barytes is made by dissolving barytes in aqueous fluo-silicic acid, till the neutral point be attained. 100 parts of the dry salt afford, by ignition, 62.25 of fluate of barytes; while 37.75 of silicated fluoric acid flies off; 100 parts of the same salt decomposed by sulphuric acid afford 82.933 of sulphate of barytes. Hence, M. Berzelius states its composition at 3 atoms of fluate of barytes, and 2 atoms of fluate of silica. *Ann. de Chim. et de Phys.* xxvii. 295. See SALT.

BARBADOES TAR. See PETROLIUM.

BARILLA, or BARILLOR. The term given in commerce to the impure soda imported from Spain and the Levant. It is made by burning to ashes different plants that grow on the sea-shore, chiefly of the genus salsola, and is brought to us in hard porous masses, of a speckled brown colour.

Kelp, a still more impure alkali made in this country by burning various sea weeds, is sometimes called *British barilla.*

BAROLITE. Carbonate of barytes.

BARRAS. The resinous incrustation on the wounds made in fir trees. It is also called galipot.

BARYSTRONTIANITE, or STROM-

NITE. A mineral found in masses of a greyish white colour externally, yellowish white and weakly shining internally. Translucent on the edges; brittle and soft, sp. grav. 3.703. Effervesces with acids, but does not melt before the blowpipe. It is composed of carbonate of strontian 68.6; sulphate of barytes 27.5; carbonate of lime 2.6; oxide of iron 0.1; loss 1.2. *Dr. Traill.* It is found in veins, or rather nests, accompanied by galena, at Stromness in Orkney.

BARYTE. See HEAVY SPAR.

BARYTES. See BARIUM.

BARYTO-CALCITE. A mineral found in Cumberland, of a slightly yellowish brown tinge, translucent, with a waxy lustre, and sp. grav. 3.66. It contains cavities which are lined with crystals in oblique rhombic prisms. The external surface is coated with sulphate of barytes. It consists, by Mr. Children's analysis, of about 2 parts, by weight, of carbonate of barytes, and 1 of carbonate of lime, which is a prime equivalent of each. *Brooke, Ann. of Phil.* N. S. viii. 114.

BASALT. Occurs in amorphous masses, columnar, amygdaloidal, and vesicular. Its colours are greyish-black, ash-grey, and raven-black. Massive. Dull lustre. Granular structure. Fracture uneven or conchoidal. Concretions; columnar, globular, or tabular. It is opaque, yields to the knife, but not easily frangible. Streak light ash-grey. Sp. gravity 3. Melts into a black glass. It is found in beds and veins in granite and mica slate, the old red sandstone, limestone, and coal formations. It is distributed over the whole world; but nowhere is met with in greater variety than in Scotland. The German basalt is supposed to be a watery deposit; and that of France to be of volcanic origin.

The most remarkable is the columnar basaltes, which forms immense masses, composed of columns thirty, forty, or more feet in height, and of enormous thickness. Nay, those at Fairhead are two hundred and fifty feet high. These constitute some of the most astonishing scenes in nature, for the immensity and regularity of their parts. The coast of Antrim in Ireland, for the space of three miles in length, exhibits a very magnificent variety of columnar cliffs: and the Giant's Causeway consists of a point of that coast formed of similar columns, and projecting into the sea upon a descent for several hundred feet. These columns are, for the most part, hexagonal, and fit very accurately together; but most frequently not adherent to each other, though water cannot penetrate between them. And the basaltic appearances on the Hebrides Islands on the coast of Scotland, as described by Sir Joseph Banks, who visited them in 1772, are upon a scale very striking for their vastness and variety.

An extensive field of inquiry is here offered to the geological philosopher, in his attempts to ascertain the alterations to which the globe has been subjected. The inquiries of the chemist equally co-operate in these researches, and tend likewise to show to what useful purposes this and other substances may be applied. Bergmann found that the component parts of various specimens of basaltes were, at a medium, 52 parts silex, 15 alumina, 8 carbonate of lime, and 25 iron. The differences seem, however, to be considerable; for Fanjas de St. Fond gives these proportions: 46 silex, 30 alumina, 10 lime, 6 magnesia, and 8 iron. The amorphous basaltes, known by the name of rowley rag, the ferrilite of Kirwan, of the specific gravity of 2.748, afforded Dr. Withering 47.5 of silex, 32.5 of alumina, and 20 of iron, at a very low degree of oxidation probably. Dr. Kennedy, in his analysis of the basaltes of Staffa, gives the following as its component parts: silex 48, alumina 16, oxide of iron 16, lime 9, soda 4, muriatic acid 1, water and volatile parts 5. Klaproth gives for the analysis of the prismatic basaltes of Hasenberg: silex 44.5, alumina 16.75, oxide of iron 20, lime 9.5, magnesia 2.25, oxide of manganese 0.12, soda 2.60, water 2. On a subsequent analysis, with a view to detect the existence of muriatic acid, he found slight indications of it, but it was in an extremely minute proportion.

Sir James Hall and Mr. Gregory Watt have both proved, by well conducted experiments, that basalt, when fused into a perfect glass, will resume the stony structure by slow cooling; and hence have endeavoured to show, that the earthy structure affords no argument against the igneous formation of basalt in the terrestrial globe.

Basaltes, when calcined and pulverized, is said to be a good substitute for puzzolana in the composition of mortar, giving it the property of hardening under water. Wine bottles have likewise been manufactured with it; but there appears to be some nicety requisite in the management to ensure success.

BASALTIC HORNBLENDE. It usually occurs in opaque six-sided single crystals, which sometimes act on the magnetic needle. It is imbedded in basalt or wacke. Colour velvet-black. Lustre vitreous. Scratches glass. Sp. gr. 3.25. Fuses with difficulty into a black glass. It consists of 47 silica, 26 alumina, 8 lime, 2 magnesia, 15 iron, and 0.5 water. It is found in the basalt of Arthur's Seat, in that of Fifeshire, and in the Isles of Mull, Canna, Eigg, and Sky. It is found also in the basaltic and floetz trap rocks of England, Ireland, Saxony, Bohemia, Silesia, Bavaria, Hungary, Spain, Italy, and France.

BASANITE. See FLINTY SLATE.

BASE or BASIS. A chemical term usually applied to alkalis, earths, and metallic oxides, in their relations to the acids and salts. It is sometimes also applied to the particular constituents of an acid or oxide, on the supposition that the substance combined with the oxygen,

&c. is the basis of the compound to which it owes its particular qualities. This notion seems unphilosophical, as these qualities depend as much on the state of combination as on the nature of the constituent.

BASSORINE. This substance is extracted from the gum resins which contain it, by treating them successively with water, alcohol, and ether. Bassorine being insoluble in these liquids, remains mixed merely with the woody particles, from which it is easy to separate it, by repeated washings and decantations; because one of its characteristic properties is to swell extremely in the water and to become very buoyant. This substance swells up in cold as well as boiling water, without any of its parts dissolving. It is soluble however almost completely by the aid of heat, in water sharpened with nitric or muriatic acid. If after concentrating with a gentle heat the nitric solution, we add highly rectified alcohol, there results a white precipitate, flocculent and bulky, which, washed with much alcohol and dried, does not form, at the utmost, the tenth of the quantity of bassorine employed, and which presents all the properties of gum-arabic. *Vauquelin*, *Bulletin de Pharmacie*, iii. 56.

BATH. The heat communicated from bodies in combustion must necessarily vary according to circumstances; and this variation not only influences the results of operations, but in many instances endangers the vessels, especially if they be made of glass. Among the several methods of obviating this inconvenience, one of the most usual consists in interposing a quantity of sand, or other matter, between the fire and the vessel intended to be heated. The sand bath and the water bath are most commonly used; the latter of which was called Balneum Mariæ by the elder chemists. A bath of steam may, in some instances, be found preferable to the water bath. Some chemists have proposed baths of melted lead, of tin, and of other fusible substances. These may perhaps be found advantageous in a few peculiar operations, in which the intelligent operator must indeed be left to his own sagacity.

A considerably greater heat may be given to the water bath by dissolving various salts in it. Thus a saturated solution of common salt boils at 225°.3. or 13°.3 Fahr. above the boiling point of water. By using solution of muriate of lime, a bath of any temperature from 212° to 252° may be conveniently obtained.

BDELLIUM. A gum resin, supposed to be of African origin. The best bdellium is of a yellowish-brown, or dark-brown colour, according to its age; unctuous to the touch, brittle, but soon softening, and growing tough betwixt the fingers; in some degree transparent, not unlike myrrh; of a bitterish taste, and a moderately strong smell. It does not easily take flame, and, when set on fire, soon goes out. In burning it sputters a little, owing to its aqueous humidity. Its sp. grav. is 1.371. Alcohol dissolves about three-fifths of bdellium, leaving a mixture of gum and cerasin. Its constituents, according to Pelletier, are 59 resin, 9.2 gum, 30.6 cerasin, 1.2 volatile oil and loss.

BEAN. The seed of the *vicia faba*, a small esculent bean, which becomes black as it ripens, has been analyzed by Einhof. He found 3840 parts to consist of 600 volatile matter, 386 skins, 610 fibrous starchy matter, 1312 starch, 417 vegeto-animal matter, 31 albumen, 136 extractive, soluble in alcohol, 177 gummy matter, 37½ earthy phosphate, 133½ loss. Fourcroy and Vauquelin found its incinerated ashes to contain the phosphates of lime, magnesia, potash, and iron, with uncombined potash. They found no sugar in this bean. Kidney beans, the seeds of the *phaseolus vulgaris*, yielded to Einhof 288 skins, 425 fibrous starchy matter, 1380 starch, 799 vegeto-animal matter, not quite free from starch, 131 extractive, 52 albumen, with some vegeto-animal matter, 744 mucilage, and 21 loss in 3840.

BEE. The venom of the bee, according to Fontana, bears a close resemblance to that of the viper. It is contained in a small vesicle, and has a hot and acrid taste, like that of the scorpion.

BEER is the wine of grain. Malt is usually made of barley. The grain is steeped for two or three days in water, until it swells, becomes somewhat tender, and tinges the water of a bright reddish-brown colour. The water being then drained away, the barley is spread about two feet thick upon a floor, where it heats spontaneously, and begins to grow, by first shooting out the radicle. In this state the germination is stopped by spreading it thinner, and turning it over for two days; after which it is again made into a heap, and suffered to become sensibly hot, which usually happens in little more than a day. Lastly, it is conveyed to the kiln, where, by a gradual and low heat, it is rendered dry and crisp. This is malt; and its qualities differ according as it is more or less soaked, drained, germinated, dried, and baked. In this, as in other manufactories, the intelligent operators often make a mystery of their processes from views of profit; and others pretend to peculiar secrets who really possess none.

Indian corn, and probably all large grain, requires to be suffered to grow into the blade, as well as root, before it is fit to be made into malt. For this purpose it is buried about two or three inches deep in the ground, and covered with loose earth; and in ten or twelve days it springs up. In this state it is taken up and washed, or fanned, to clear it from its dirt; and then dried in the kiln for use.

Barley, by being converted into malt, becomes one-fifth lighter, or 20 per cent.; 12 of which are owing to kiln drying, 1.5 are carried off by the steep-water, 3 dissipated on the floor, 3 lost in cleaning the roots, and 0.5 waste or loss.

The degree of heat to which the malt is exposed in this process, gradually changes its colour from very pale to actual blackness, as it simply dries it, or converts it to charcoal.

The colour of the malt not only affects the colour of the liquor brewed from it, but, in consequence of the chemical operation, of the heat applied, on the principles that are developed in the grain during the process of malting, materially alters the quality of the beer, especially with regard to the properties of becoming fit for drinking and growing fine.

Beer is made from malt previously ground, or cut to pieces by a mill. This is placed in a tun, or tub with a false bottom; hot water is poured upon it, and the whole stirred about with a proper instrument. The temperature of the water in this operation, called Mashing, must not be equal to boiling; for, in that case, the malt would be converted into a paste, from which the impregnated water could not be separated. This is called Setting. After the infusion has remained for some time upon the malt, it is drawn off, and is then distinguished by the name of Sweet Wort. By one or more subsequent infusions of water, a quantity of weaker wort is made, which is either added to the foregoing, or kept apart, according to the intention of the operator. The wort is then boiled with hops, which give it an aromatic bitter taste, and are supposed to render it less liable to be spoiled in keeping; after which it is cooled in shallow vessels, and suffered to ferment, with the addition of a proper quantity of yeast. The fermented liquor is beer; and differs greatly in its quality, according to the nature of the grain, the malting, the mashing, the quantity and kind of the hops and the yeast, the purity or admixtures of the water made use of, the temperature and vicissitudes of the weather, &c.

Beside the various qualities of malt liquors of a similar kind, there are certain leading features by which they are distinguished, and classed under different names, and to produce which, different modes of management must be pursued. The principal distinctions are into beer, properly so called; ale; table or small beer; and porter, which is commonly termed beer in London. Beer is a strong, fine, and thin liquor; the greater part of the mucilage having been separated by boiling the wort longer than for ale, and carrying the fermentation farther, so as to convert the saccharine matter into alcohol. Ale is of a more sirupy consistence, and sweeter taste; more of the mucilage being retained in it, and the fermentation not having been carried so far as to decompose all the sugar. Small beer, as its name implies, is a weaker liquor; and is made either by adding a large portion of water to the malt, or by mashing with a fresh quantity of water what is left after the beer or ale wort is drawn off. Porter was probably made originally from very high dried malt; but it is said, that its peculiar flavour cannot be imparted by malt and hops alone.

Mr. Brande obtained the following quantities of alcohol from 100 parts of different species of beers. Burton ale, 8.88, Edinburgh ale, 6.2, Dorchester ale, 5.56; the average being = 6.87. Brown stout, 6.8, London porter (average) 4.2, London small beer (average) 1.28.

As long ago as the reign of Queen Anne, brewers were forbid to mix sugar, honey, Guinea pepper, essentia bina, cocculus indicus, or any other unwholesome ingredient, in beer, under a certain penalty; from which we may infer, that such at least was the practice of some; and writers, who profess to discuss the secrets of the trade, mention most of these, and some other articles, as essentially necessary. The essentia bina is sugar boiled down to a dark colour, and empyreumatic flavour. Broom tops, wormwood, and other bitter plants, were formerly used to render beer fit for keeping, before hops were introduced into this country; but are now prohibited to be used in beer made for sale.

By the present law of this country, nothing is allowed to enter into the composition of beer, except malt and hops. Quassia and wormwood are often fraudulently introduced; both of which are easily discoverable by their nauseous bitter taste. They form a beer which does not preserve so well as hop beer. Sulphate of iron, alum, and salt, are often added by the publicans, under the name of *beer-heading*, to impart a frothing property to beer, when it is poured out of one vessel into another. Molasses and extract of gentian root are added with the same view. Capsicum, grains of paradise, ginger root, coriander seed, and orange peel, are also employed to give pungency and flavour to weak or bad beer. The following is a list of some of the unlawful substances seized at different breweries, and brewers' druggists' laboratories, in London, as copied from the minutes of the committee of the House of Commons. Cocculus indicus multum (an extract of the cocculus), colouring, honey, hartshorn shavings, Spanish juice, orange powder, ginger, grains of paradise, quassia, liquorice, caraway seeds, copperas, capsicum, mixed drugs. Sulphuric acid is very frequently added to *bring beer forward*, or make it hard, giving new beer instantly the taste of what is 18 months old. According to Mr. Accum, the present *entire* beer of the London brewer is composed of all the waste and spoiled beer of the publicans, the bottoms of butts, the leavings of the pots, the drippings of the machines for drawing the beer, the remnants of beer that lay in the leaden pipes of the brewery, with a portion of brown stout, bottling beer, and mild beer. He says that opium, tobacco, nux vomica, and extract of poppies, have been likewise used to adulterate beer. For an account of the poisonous qualities of the *cocculus indicus*, see PICROTOXIA; and for those of nux vomica, see STRYCHNIA. By evaporating a portion of beer to dryness, and igniting the residuum with chlorate of potash, the iron of the copperas will be procured in an insoluble oxide. Muriate of barytes will throw down an abundant precipitate from beer contaminated with sulphuric acid or copperas; which precipitate may be collected, dried, and ignited. It will be insoluble in nitric acid.

Beer appears to have been of ancient use, as Tacitus mentions it among the Germans, and has been usually supposed to have been peculiar to the northern nations: but the ancient Egyptians, whose country was not adapted to the culture of the grape, had also contrived this substitute for wine; and Mr. Park has found the art of making malt, and brewing from it very good beer, among the negroes in the interior parts of Africa.

BEET. The root of the beet affords a considerable quantity of sugar, and has lately been cultivated for the purpose of extracting it to some extent in Germany. See SUGAR. It is likewise said, that if beet roots be dried in the same manner as malt, after the greater part of their juice is pressed out, very good beer may be made from them.

BELLADONNA, the plant called in English Deadly Nightshade, from which the alkaline matter ATROPIA is extracted. M. Runge says, that the narcotic principle of belladonna is destroyed, or so changed, by alkaline solutions, as to lose its distinguishing property of causing dilatation of the pupil. This takes place when the solutions are weak or even with lime water; so that this principle cannot be obtained by the usual process through the intervention of alkalis. Magnesia exerts no action of this kind; and it should be used as a hydrate uncalcined. It should be thrown down from sulphate of magnesia by potash not in sufficient quantity to decompose the whole salt, the mixture added to the aqueous infusion of belladonna, and the whole evaporated by a brisk fire to dryness; the residuum when dried and pulverized, is to be treated with highly rectified alcohol. The clear yellow solution being evaporated spontaneously, yields a crystalline mass, which slightly blues reddened litmus paper, dissolves in water, and produces extreme dilatation of the pupil. Its salts have also the same effect. *Ann. de Chimie*, xxvii. 32.

BELLMETAL. See COPPER.

BELLMETAL ORE. See ORES OF TIN.

BEN (OIL OF). This is obtained from the ben nut by simple pressure. It is remarkable for its not growing rancid in keeping, or at least not until it has stood for a number of years; and on this account it is used in extracting the aromatic principle of such odoriferous flowers as yield little or no essential oil in distillation.

BENZOIC ACID. See ACID (BENZOIC).

BENZOIN, or BENJAMIN. The tree which produces benzoin is a native of the East Indies, particularly of the island Siam and Sumatra*. The juice exudes from incisions, in the form of a thick white balsam. If collected as soon as it has grown somewhat solid, it proves internally white like almond, and hence it is called Benzoë Amygdaloides: if suffered to lie long exposed to the sun and air, it changes more and more to a brownish, and at last to a quite reddish-brown colour.

This resin is moderately hard and brittle, and yields an agreeable smell when rubbed or warmed. When chewed, it impresses a slight sweetness on the palate. It is totally soluble in alcohol; from which, like other resins, it may be precipitated by the addition of water. Its specific gravity is 1.092.

The white opaque fluid thus obtained has been called Lac Virginale; and is still sold, with other fragrant additions, by perfumers, as a cosmetic. Boiling water separates the peculiar acid of benzoin.

The products Mr. Brande obtained by distillation were, from 100 grains, benzoic acid 9 grains, acidulated water 5.5, butyraceous and empyreumatic oil 60, brittle coal 22, and a mixture of carburetted hydrogen and carbonic acid gas, computed at 3.5. On treating the empyreumatic oil with water, however, 5 grains more of acid were extracted, making 14 in the whole.

From 1500 grains of benzoin, Bucholz obtained 1250 of resin, 187 benzoic acid, 25 of a substance similar to balsam of Peru, 8 of an aromatic substance soluble in water and alcohol, and 30 of woody fibres and impurities.

Ether, sulphuric, and acetic acids, dissolve benzoin; so do solutions of potash and soda. Nitric acid acts violently on it, and a portion of artificial tannin is formed. Ammonia dissolves it sparingly.

BERGMANNITE. A massive mineral of a greenish, greyish-white, or reddish colour. Lustre intermediate between pearly and resinous. Fracture fibrous, passing into fine grained, uneven. Slightly translucent on the edges. Scratches felspar. Fuses into a transparent glass, or a semitransparent enamel. It is found at Fredrickswarn in Norway, in quartz and in felspar.

BERYL. This precious mineral is most commonly green, of various shades, passing into honey-yellow, and sky-blue. It is crystallized in hexahedral prisms deeply striated longitudinally, or in 6 or 12 sided prisms, terminated by a 6 sided pyramid, whose summit is replaced. It is harder than the emerald, but more readily yields to cleavage. Its sp. grav. is 2.7. Its lustre is vitreous. It is transparent, and sometimes only translucent. It consists by Vauquelin of 68 silica, 15 alumina, 14 glucina, 1 oxide of iron, 2 lime. Berzelius found in it a trace of oxide of tantalum. It occurs in veins traversing granite in Daouria; in the Altaic chain in Siberia; near Limoges in France; in Saxony; Brazil; at Kinlock Raimoch, and Cairngorm, Aberdeenshire, Scotland; above Dundrum, in the county of Dublin, and near Cronebane, county of Wicklow, in Ireland. It differs from emerald in hardness and colour. It has been called aqua marine, and greenish-yellow emerald. It is electric by friction, and not by heat.

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* Consult the Philosophical Transactions, vol. lxxvii. p. 307. for a botanical description and drawing of the tree, by Dryander.

BEUDANTITE. A new mineral occurring in small crystals closely aggregated, being slightly obtuse rhombohedrons with the summits truncated. Colour black; lustre resinous; in thin fragments translucent, and of a deep brown colour. Primitive form, an obtuse rhomboid of 92° 30′. Hardness greater than that of fluate of lime. Powder greenish-grey. It comes from Hohrhausen on the Rhine. The only substances that Dr. Wollaston could detect in it were oxide of lead and oxide of iron. *Annals of Phil.* xi. 196.

BEZOAR. This name, which is derived from a Persian word implying an antidote to poison, was given to a concretion found in the stomach of an animal of the goat kind, which was once very highly valued for this imaginary quality, and has thence been extended to all concretions found in animals.

These are of eight kinds, according to Fourcroy, Vauquelin, and Berthollet. 1. Superphosphate of lime, which forms concretions in the intestines of many *mammalia*. 2. Phosphate of magnesia, semitransparent and yellowish, and of sp. grav. 2.160. 3. Phosphate of ammonia and magnesia. A concretion of a grey or brown colour, composed of radiations from a centre. It is found in the intestines of herbiverous animals, the elephant, horse, &c. 4. Biliary, colour reddish-brown, found frequently in the intestines and gall bladder of oxen, and used by painters for an orange-yellow pigment. It is inspissated bile. 5. Resinous. The oriental bezoars, procured from unknown animals, belong to this class of concretions. They consist of concentric layers, are fusible, combustible, smooth, soft, and finely polished. They are composed of bile and resin. 6. Fungous, consisting of pieces of the boletus igniarius, swallowed by the animal. 7. Hairy. 8. Ligniform. Three bezoars sent to Bonaparte by the king of Persia were found by Berthollet to be nothing but woody fibre agglomerated.

BIHYDROGURET OF CARBON. See Carburetted Hydrogen.

BIHYDROGURET OF PHOSPHORUS. See Phosphuretted Hydrogen.

BILDSTEIN, AGALMATOLITE, or FIGURESTONE. A massive mineral, with sometimes an imperfectly slaty structure. Colour grey, brown, flesh-red, and sometimes spotted, or with blue veins. It is translucent on the edges, unctuous to the touch, and yields to the nail. Sp. grav. 2.8. It is composed of 56 silica, 29 alumina, 7 potash, 2 lime, 1 oxide of iron, and 5 water, by Vauquelin. Klaproth found in a specimen from China, 54.5 silica, 34 alumina, 6.25 potash, 0.75 oxide of iron, and 4 water. It fuses into a transparent glass. M. Brogniart calls it *steatite pagodite* from its coming from China cut into grotesque figures. It wants the magnesia, which is a constant ingredient of steatites. It is found at Naygag in Transylvania, and Glyderbach in Wales.

BILE. A bitter liquid, of a yellowish or greenish-yellow colour, more or less viscid, of a sp. gravity greater than that of water, common to a great number of animals, the peculiar secretion of their liver. It is the prevailing opinion of physiologists, that the bile is separated from the venous, and not, like the other secretions, from the arterial blood. The veins which receive the blood distributed to the abdominal viscera, unite into a large trunk called the *vena portæ*, which divides into two branches, that penetrate into the liver, and divide into innumerable ramifications. The last of these terminate partly in the biliary ducts, and partly in the hepatic veins, which restore to the circulation the blood not needed for the formation of bile. This liquid passes directly into the duodenum by the *ductus choledocus*, when the animal has no gall bladder; but when it has one, as more frequently happens, the bile flows back into it by the cystic duct, and remaining there for a longer or shorter time, experiences remarkable alterations. Its principal use seems to be, to promote the duodenal digestion, in concert with the pancreatic juice.

Boerhaave, by an extravagant error, regarded the bile as one of the most putrescible fluids; and hence originated many hypothetical and absurd theories on diseases and their treatment. We shall follow the arrangement of M. Thenard, in a subject which owes to him its chief illustration.

Ox bile is usually of a greenish-yellow colour, rarely a deep green. By its colour it changes the blue of turnsole and violet to a reddish-yellow. At once very bitter, and slightly sweet, its taste is scarcely supportable. Its smell, though feeble, is easy to recognize, and approaches somewhat to the nauseous odour of certain fatty matters when they are heated. Its specific gravity varies very little. It is about 1.026 at 43° F. It is sometimes limpid, and at others disturbed with a yellow matter, from which it may be easily separated by water: its consistence varies from that of a thin mucilage, to viscidity. Cadet regarded it as a kind of soap. This opinion was first refuted by M. Thenard. According to this able chemist, 800 parts of ox bile are composed of 700 water, 15 resinous matter, 69 picromel, about 4 of a yellow matter, 4 of soda, 2 phosphate of soda, 3.5 muriates of soda and potash, 0.8 sulphate of soda, 1.2 phosphate of lime, and a trace of oxide of iron. When distilled to dryness, it leaves from 1-8th to 1-9th of solid matter, which, urged with a higher heat, is resolved into the usual igneous products of animal analysis; only with more oil and less carbonate of ammonia.

Exposed for some time in an open vessel, the bile gradually corrupts, and lets fall a small quantity of a yellowish matter; then its mucilage decomposes. Thus the putrefactive process is very inactive, and the odour it exhales is not insupportable, but in some cases has been thought to resemble that of musk. Water and alcohol combine in all proportions with bile. When a very little acid is poured into bile, it becomes slightly turbid, and reddens litmus; when more is added, the precipitate augments, particularly if sulphuric acid be employed. It is formed of a yellow animal matter, with very little resin. Potash and soda increase the thinness and transparency of bile. Acetate of lead precipitates the yellow matter, and the sulphuric and phosphoric acids of the bile. The solution of the subacetate precipitates not only these bodies, but also the picromel and the muriatic acid, all combined with the oxide of lead. The acetic acid remains in the liquid united to the soda. The greater number of fatty substances are capable of being dissolved by bile. This property, which made it be considered a soap, is owing to the soda, and to the triple compound of soda, resin, and picromel. Scourers sometimes prefer it to soap, for cleansing woollen. The bile of the calf, the dog, and the sheep, are similar to that of the ox. The bile of the sow contains no picromel. It is merely a soda-resinous soap. Human bile is peculiar. It varies in colour, sometimes being green, generally yellowish-brown, occasionally almost colourless. Its taste is not very bitter. In the gall bladder it is seldom limpid, containing often, like that of the ox, a certain quantity of yellow matter in suspension. At times this is in such quantity, as to render the bile somewhat grumous. Filtered and boiled, it becomes very turbid, and diffuses the odour of white of egg. When evaporated to dryness, there results a brown extract, equal in weight to 1-11th of the bile. By calcination we obtain the same salts as from ox bile.

All the acids decompose human bile, and occasion an abundant precipitate of albumen and resin, which are easily separable by alcohol. One part of nitric acid, sp. grav. 1.210, saturates 100 of bile. On pouring into it a solution of sugar of lead, it is changed into a liquid of a light-yellow colour, in which no picromel can be found, and which contains only acetate of soda and some traces of animal matter. Human bile appears hence to be formed, by Thenard, in 1100 parts; of 1000 water; from 2 to 10 yellow insoluble matter; 42 albumen; 41 resin; 5.6 soda; and 45 phosphates of soda and lime, sulphate of soda, muriate of soda, and oxide of iron. But by Berzelius, its constituents are in 1000 parts; 908.4 water; 80 picromel; 3 albumen; 4.1 soda; 0.1 phosphate of lime; 3.4 common salt; and 1 phosphate of soda, with some phosphate of lime.

BIRDLIME. The best birdlime is made of the middle bark of the holly, boiled seven or eight hours in water, till it is soft and tender; then laid in heaps in pits in the ground and covered with stones, the water being previously drained from it; and in this state left for two or three weeks to ferment, till it is reduced to a kind of mucilage. This being taken from the pit is pounded in a mortar to a paste, washed in river water, and kneaded, till it is freed from extraneous matters. In this state it is left four or five days in earthen vessels, to ferment and purify itself, when it is fit for use.

It may likewise be obtained from the mistletoe, the viburnum lantana, young shoots of elder, and other vegetable substances.

It is sometimes adulterated with turpentine, oil, vinegar, and other matters.

Good birdlime is of a greenish colour, and sour flavour; gluey, stringy, and tenacious; and in smell resembling linseed oil. By exposure to the air it becomes dry and brittle, so that it may be powdered; but its viscidity is restored by wetting it. It reddens tincture of litmus. Exposed to a gentle heat it liquefies slightly, swells in bubbles, becomes grumous, emits a smell resembling that of animal oils, grows brown, but recovers its properties on cooling, if not heated too much. With a greater heat it burns, giving out a brisk flame and much smoke. The residuum contains sulphate and muriate of potash, carbonate of lime and alumina, with a small portion of iron.

BISMUTH is a metal of a yellowish or reddish-white colour, little subject to change in the air. It is somewhat harder than lead, and is scarcely, if at all malleable; being easily broken, and even reduced to powder, by the hammer. The internal face, or place of fracture, exhibits large shining plates, disposed in a variety of positions; thin pieces are considerably sonorous. At a temperature of 480° Fahrenheit, it melts, and its surface becomes covered with a greenish-grey or brown oxide. A stronger heat ignites it, and causes it to burn with a small blue flame; at the same time that a yellowish oxide, known by the name of flowers of bismuth, is driven up. This oxide appears to rise in consequence of the combustion; for it is very fixed, and runs into a greenish glass when exposed to heat alone.

This oxide consists of 100 metal + 11.275 oxygen, whence its prime equivalent will be 9.87, and that of the metal itself 8.87. The specific gravity of the metal is 9.85.

Bismuth urged by a strong heat in a closed vessel, sublimes entire, and crystallizes very distinctly when gradually cooled.

Sulphuric acid has a slight action upon bismuth, when it is concentrated and boiling. Sulphurous acid gas is exhaled, and part of the bismuth is converted into a white oxide. A small portion combines with the sulphuric acid, and affords a deliquescent salt in the form of small needles.

Nitric acid dissolves bismuth with the greatest rapidity and violence; at the same time that much heat is extricated, and a large quantity of nitric oxide escapes. The solution, when saturated, affords crystals as it cools; the salt detonates weakly, and leaves a yellow oxide behind, which effloresces in the air. Upon dissolving this salt in water, it renders that fluid of a milky white, and lets fall an oxide of the same colour.

The nitric solution of bismuth exhibits the same property when diluted with water, most of the metal falling down in the form of a white oxide, called magistery of bismuth. This precipitation of the nitric solution, by the addition of water, is the criterion by which bismuth is distinguished from most other metals. The magistery, or oxide, is a very white and subtile powder; when prepared by the addition of a large quantity of water, it is used as a paint for the complexion, and is thought gradually to impair the skin. The liberal use of any paint for the skin seems indeed likely to do this; but there is reason to suspect, from the resemblance between the general properties of lead and bismuth, that the oxide of this metal may be attended with effects similar to those which the oxides of lead are known to produce. If a small portion of muriatic acid be mixed with the nitric, and the precipitated oxide be washed with but a small quantity of cold water, it will appear in minute scales of a pearly lustre, constituting the *pearl powder* of perfumers. These paints are liable to be turned black by sulphuretted hydrogen gas.

Muriatic acid does not readily act upon bismuth.

When bismuth is exposed to chlorine gas it takes fire, and is converted into a chloride, which, formerly prepared by heating the metal with corrosive sublimate, was called butter of bismuth. The chloride is of a greyish-white colour, a granular texture, and is opaque. It is fixed at a red heat. According to Dr. John Davy, it is composed of 33.6 chlorine, + 66.4 bismuth, = 100; or in equivalent numbers, of 4.5 chlorine, + 8.87 bismuth, = 13.37. When iodine and bismuth are heated together, they readily form an iodide of an orange-yellow colour, insoluble in water, but easily dissolved in potash ley.

Alkalis likewise precipitate its oxide; but not of so beautiful a white colour as that afforded by the affusion of pure water.

The gallic acid precipitates bismuth of a greenish-yellow, as ferroprussiate of potash does of a yellowish colour.

There appears to be two sulphurets, the first a compound of 100 bismuth to 22.34 sulphur; the second of 100 to 46.5: the second is a bisulphuret.

This metal unites with most metallic substances, and renders them in general more fusible. When calcined with the imperfect metals, its glass dissolves them, and produces the same effect as lead in cupellation; in which process it is even said to be preferable to lead.

Bismuth is used in the composition of pewter, in the fabrication of printers' types, and in various other metallic mixtures. With an equal weight of lead, it forms a brilliant white alloy, much harder than lead, and more malleable than bismuth, though not ductile; and if the proportion of lead be increased, it is rendered still more malleable. Eight parts of bismuth, five of lead, and three of tin, constitute the fusible metal, sometimes called Newton's, from its discoverer, which melts at the heat of boiling water, and may be fused over a candle in a piece of stiff paper without burning the paper. One part of bismuth, with five of lead, and three of tin, forms pewterer's solder. It forms the basis of a sympathetic ink. The oxide of bismuth precipitated by potash from nitric acid has been recommended in spasmodic disorders of the stomach, and given in doses of four grains, four times a-day. A writer in the Jena Journal says he has known the dose carried gradually to one scruple without injury.

Bismuth is easily separable, in the dry way, from its ores, on account of its great fusibility. It is usual, in the processes at large, to throw the bismuth ore into a fire of wood; beneath which a hole is made in the ground to receive the metal, and defend it from oxidation. The same process may be imitated in the small way, in the examination of the ores of this metal; nothing more being necessary, than to expose it to a moderate heat in a crucible, with a quantity of reducing flux; taking care, at the same time, to perform the operation as speedily as possible, that the bismuth may be neither oxidized nor volatilized. See Salt.

BISTRE. A brown pigment, consisting of the finer parts of wood soot, separated from the grosser by washing. The soot of the beech is said to make the best.

BISULPHATE. See Sulphate, under Acid (Sulphuric).

BITTER PRINCIPLE, of which there are several varieties.

When nitric acid is digested on silk, indigo, or white willow, a substance of a deep yellow colour, and an intensely bitter taste, is formed. It dyes a permanent yellow. It crystallizes in oblong plates, and saturates alkalis, like an acid, producing crystallizable salts. That with potash is in yellow prisms. They are bitter, permanent in the air, and less soluble than the insulated bitter principle. On hot charcoal they deflagrate. When struck smartly on an anvil, they detonate with much violence, and with emission of a purple light. Ammonia deepens the colour of the bitter principle solution, and forms a salt in yellow spiculæ. It unites also with the alkaline earths and metallic oxides. M. Chevreul considers it a compound of nitric acid, with a peculiar substance of an oily nature. Quassia, cocculus indicus, daphne Alpina, coffee, squills, colocynth, and bryony, as well as many other medicinal plants, yield bitter principles, peculiarly modified.

BITTERN. The mother water which remains after the crystallization of common salt in sea water, or the water of salt springs. It abounds with sulphate and muriate of magnesia, to which its bitterness is owing. See Water (Sea).

BITTERSPAR, or RHOMBSPAR. This mineral crystallizes in rhomboids, which were confounded with those of calcareous spar, till Dr. Wollaston applied his admirable reflective goniometer, and proved the peculiarity of the angles in bitterspar, which are 106° 15′ and 73° 45′. Its colour is greyish or yellow, with a somewhat pearly lustre. It is brittle, semitransparent, splendent, and harder than calcareous spar. Fracture straight, foliated, with a threefold cleavage. Its sp. gr. is 2.88. It consists of from 68 to 73 carbonate of lime, 25 carbonate of magnesia, and 2 oxide of manganese. It is usually embedded in serpentine, chlorite, or steatite; and is found in the Tyrol, Salsburg, and Dauphiny. In Scotland, on the borders of Loch Lomond in chlorite slate, and near Newton Stewart, in Galloway; as also in the Isle of Man. It bears the same relation to dolomite and magnesian limestone, that calcareous spar does to common limestone.*

BITUMEN. This term includes a considerable range of inflammable mineral substances, burning with flame in the open air. They are of different consistency, from a thin fluid to a solid; but the solids are for the most part liquefiable at a moderate heat. The fluid are, 1. Naphtha; a fine, white, thin, fragrant, colourless oil, which issues out of white, yellow, or black clays in Persia and Media. This is highly inflammable, and is decomposed by distillation. It dissolves resins, and the essential oils of thyme and lavender; but is not itself soluble either in alcohol or ether. It is the lightest of all the dense fluids, its specific gravity being 0.708. 2. Petroleum, which is a yellow, reddish, brown, greenish, or blackish oil, found dropping from rocks, or issuing from the earth, in the duchy of Modena, and in various other parts of Europe and Asia. This likewise is insoluble in alcohol, and seems to consist of naphtha, thickened by exposure to the atmosphere. It contains a portion of the succinic acid. 3. Barbadoes tar, which is a viscid, brown, or black inflammable substance, insoluble in alcohol, and containing the succinic acid. This appears to be the mineral oil in its third state of alteration. The solid are, 1. Asphaltum, mineral pitch, of which there are three varieties; the cohesive; the semi-compact, maltha; the compact, or asphaltum. These are smooth, more or less hard or brittle, inflammable substances, which melt easily, and burn without leaving any or but little ashes, if they be pure. They are slightly and partially acted on by alcohol and ether. 2. Mineral tallow, which is a white substance of the consistence of tallow, and as greasy, although more brittle. It was found in the sea on the coasts of Finland, in the year 1736; and is also met with in some rocky parts of Persia. It is near one-fifth lighter than tallow; burns with a blue flame, and a smell of grease, leaving a black viscid matter behind, which is more difficultly consumed. 3. Elastic bitumen, or mineral caoutchouc, of which there are two varieties. Beside these, there are other bituminous substances, as jet and amber, which approach the harder bitumens in their nature; and all the varieties of pit-coal, and the bituminous schistus, or shale, which contain more or less of bitumen in their composition. See the different kinds of bitumen and bituminous substances, in their respective places in the order of the alphabet.

BITUMINOUS LIMESTONE is of a lamellar structure, susceptible of polishing, emits an unpleasant smell when rubbed, and has a brown or black colour. Heat converts it into quicklime. It contains 8.8 alumina; 0.6 silica; 0.6 bitumen; and 89.75 carbonate of lime. It is found near Bristol, and in Galway, in Ireland. The Dalmatian is so charged with bitumen, that it may be cut like soap, and is used for building houses. When the walls are reared, fire is applied to them, and they burn white.

BLACK CHALK. This mineral has a bluish-black colour; a slaty texture; soils the fingers, and is meagre to the touch. It contains about 64 silica, 11 alumina, 11 carbon, with a little iron and water. It is found in primitive mountains, and also sometimes near coal formations. It occurs in Caernarvonshire, and in the island of Isla.

BLACK JACK. The miners distinguish blende, or mock lead, by this name. It is an ore of zinc.

BLACK LEAD. See PLUMBAGO.

BLACK WADD. One of the ores of manganese.

BLEACHING. The chemical art by which the various articles used for clothing are deprived of their natural dark colour and rendered white.

The colouring principle of silk is undoubtedly resinous. Hence M. Baumé proposed the following process, as the best mode of bleaching it. On six pounds of yellow raw silk, disposed in an earthen pot, 48 pounds of alcohol, sp. gr. 0.867, mixed with 12 oz. muriatic acid, sp. gr. 1.100, are to be poured. After a day's digestion, the liquid passes from a fine green colour to a dusky brown. The silk is then to be drained, and washed with alcohol. A second infusion with the above acidulated alcohol is then made, for four or six days, after which the silk is drained and washed with alcohol. The spirit may be recovered by saturating the mingled acid with alkali or lime, and distilling. M. Baumé says, that silk may thus be made to rival or surpass in whiteness and lustre the finest specimens from Nankin. But the ordinary method of bleaching silk is the following:—The silk, being still raw, is put into a bag of thin linen, and thrown into a vessel of boiling river water, in which has been dissolved good Genoa or Toulon soap.

After the silk has boiled two or three hours in that water, the bag being frequently turned, it is taken out to be beaten, and is then washed in cold water. When it has been thus thoroughly washed and beaten, they wring it slightly, and put it for the second time into the boiling vessel, filled with cold water, mixed with soap and a little indigo; which gives it that bluish cast commonly observed in white silk.

When the silk is taken out of this second water, they wring it hard with a wooden peg, to press out all the water and soap; after which they shake it, to untwist it, and separate the threads. Then they suspend it in a kind of stove constructed for that purpose, where they burn sulphur; the vapour of which gives the last degree of whiteness to the silk.

The method of bleaching woollen stuffs.—There are three ways of doing this. The first is with water and soap; the second with the vapour of sulphur; and the third with chalk, indigo, and the vapour of sulphur.

Bleaching with soap and water.—After the stuffs are taken out of the fuller's mill, they are put into soap and water, a little warm, in which they are again worked by the strength of the arms over a wooden bench: this finishes giving them the whitening which the fuller's mill had only begun. When they have been sufficiently worked with the hands, they are washed in clear water and put to dry.

This method of bleaching woollen stuffs is called the Natural Method.

Bleaching with sulphur.—They begin with washing and cleansing the stuffs thoroughly in river water; then they put them to dry upon poles or perches. When they are half dry, they stretch them out in a very close stove, in which they burn sulphur; the vapour of which diffusing itself, adheres by degrees to the whole stuff, and gives it a fine whitening: this is commonly called Bleaching by the Flower, or Bleaching of Paris, because they use this method in that city more than any where else.

The colouring matter of linen and cotton is also probably resinous; at least the experiments of Mr. Kirwan on alkaline lixivia saturated with the dark colouring matter, lead to that conclusion. By neutralizing the alkali with dilute muriatic acid, a precipitate resembling lac was obtained, soluble in alcohol, in solutions of alkalis, and alkaline sulphurets.

The first step towards freeing vegetable yarn or cloth from their native colour is fermentation. The raw goods are put into a large wooden tub, with a quantity of used alkaline lixivium, in an acescent state, heated to about the hundredth degree of Fahr. It would be better to use some uncoloured fermentable matter, such as soured bran or potatoe paste, along with *clean* warm water. In a short time an intestine motion arises, air bubbles escape, and the goods swell, raising up the loaded board which is used to press them into the liquor. At the end of from 18 to 48 hours, according to the quality of the stuffs, the fermentation ceases, when the goods are to be immediately withdrawn and washed. Much advantage may be derived by the skilful bleacher, from conducting the acetous fermentation completely to a close, without incurring the risk of injuring the fibre by the putrefactive fermentation.

The goods are next exposed to the action of hot alkaline lixivia, by bucking or boiling, or both. The former operation consists in pouring boiling hot ley on the cloth placed in a tub; after a short time drawing off the cooled liquid below, and replacing it above by hot lixivium. The most convenient arrangement of apparatus is the following:—Into the mouth of an egg-shaped iron boiler, the bottom of a large tub is fixed air-tight. The tub is furnished with a false bottom pierced with holes, a few inches above the real bottom. In the latter, a valve is placed, opening downwards, but which may be readily closed by the upward pressure of steam. From the side of the iron boiler, a little above its bottom, a pipe issues, which, turning at right angles upwards, rises parallel to the outside of the bucking tub, to a foot or two above its summit. The vertical part of this pipe forms the cylinder of a sucking pump, and has a piston and rod adapted to it. At a few inches above the level of the mouth of the tub, the vertical pipe sends off a lateral branch, which terminates in a bent down nozzle, over a hole in the centre of the lid of the tub. Under the nozzle, and immediately within the lid, is a metallic circular disc. The boiler being charged with lixivium, and the tub with the washed goods, a moderate fire is kindled. At the same time, the pump is set a-going either by the hand of a workman, or by machinery. Thus the lixivium, in its progressively heating state, is made to circulate continually down through the stuffs. But when it finally attains the boiling temperature, the piston rod and piston are removed, and the pressure of the included steam alone forces the liquid up the vertical pipe, and along the horizontal one in an uninterrupted stream. The valve at the bottom of the tub, yielding to the accumulated weight of the liquid, opens from time to time, and replaces the lixivium in the boiler.

This ingenious self-acting apparatus was invented by Mr. John Laurie of Glasgow, and a representation of it accompanies Mr. Ramsay's excellent article, Bleaching, in the Edinburgh Encyclopædia. By its means, labour is spared, the negligence of servants is guarded against, and fully one-fourth of alkali saved.

It is of great consequence to heat the liquid very slowly at first. Hasty boiling is incompatible with good bleaching. When the ley seems to be impregnated with colouring matter, the fire is lowered, and the liquid drawn off by a stop-cock; at the same time that water, at first hot and then cold, is run in at top, to separate all the dark-coloured lixivium. The goods are then taken out and well washed, either by the hand with the wash stocks, or by the rotary wooden wheel with hollow compartments, called the dash wheel. The strength of the alkaline lixivium is varied by different bleachers. A solution of potash, rendered caustic by lime, of the specific gravity 1.014, or containing a little more than 1 per cent. of pure potash, is used by many bleachers. The Irish bleachers use barilla lixivium chiefly, and of inferior alkaline power. The routine of operations may be conveniently presented in a tabular form.

A parcel of goods consists of 360 pieces of those linens which are called Britannias. Each piece is 35 yards long, weighing on an average 10 pounds. Hence the weight of the whole is 3600 pounds avoirdupois. These linens are first washed, and then subjected to the acetous fermentation, as above described. They then undergo the following operations:—

1. Bucked with 60 lbs. pearl ashes, washed and exposed on the field.
2. Ditto with 80 lbs. ditto ditto.
3. Ditto 90 potashes ditto.
4. Ditto 80 ditto ditto.
5. Ditto 80 ditto ditto.
6. Ditto 50 ditto ditto.
7. Ditto 70 ditto ditto.
8. Ditto 70 ditto ditto.
9. Soured one night in dilute sulphuric acid.
10. Bucked with 50 lbs. pearl ashes, washed and exposed.
11. Immersed in the oxymuriate of potash for 12 hours.
12. Boiled with 30 lbs. pearl ashes, washed and exposed.
13. Ditto 30 ditto ditto.
14. Soured and washed.

The linens are then taken to the rubbing board, and well rubbed with a strong lather of black soap, after which they are well washed in pure spring water. At this period they are carefully examined, and those which are fully bleached are laid aside to be blued and made up for the market. Those which are not fully white, are returned to be boiled and steeped in the oxymuriate of potash, and soured until they are fully white. By the above process, 690 lbs. of commercial alkali are used in bleaching 360 pieces of linen, each measuring 35 yards. Hence, the expenditure of alkali would be a little under 2 lbs. a-piece, were it not that some part of the above linens may not be thoroughly whitened. It will, therefore, be a fair average to allow 2 lbs. for each piece of such goods.

On the above process we may remark, that many enlightened bleachers have found it advantageous to apply the souring at a more early period, as well as the oxymuriatic solution. According to Dr. Stephenson, in his elaborate paper on the linen and hempen manufactures, published by the Belfast Literary Society, 16 naggins, or quarter pints of oil of vitriol, are sufficient to make 200 gallons of souring. This gives the proportion, by measure, of 640 water to 1 of acid. Mr. Parkes, in describing the bleaching of calicoes in his Chemical Essays, says, that throughout Lancashire, one *measure* of sulphuric acid is used with 46 of water, or one *pound* of the acid to 25 pounds of water; and he states, that a scientific calico printer in Scotland makes his sours to have the specific gravity 1.0254 at 110° of Fahrenheit; which dilute acid contains at least 1-25th of oil of vitriol. Five or six hours' immersion is employed.

In a note Mr. Parkes adds, that in bleaching common goods, and such as are not designed for the best printing, the specific gravity of the sours is varied from 1.0146 to 1.0238, if taken at the atmospheric temperature. Most bleachers use the strongest alkaline lixiviums at first, and the weaker afterwards. As to the strength of the oxymuriatic steeps, as the bleacher terms them, it is difficult to give certain data, from the variableness of the chlorides of potash and lime.

Mr. Parkes, in giving the process of the Scotch bleacher, says, that after the calicoes have been singed, steeped, and squeezed, they are boiled four successive times, for 10 or 12 hours each, in a solution of caustic potash of a specific gravity from 1.0127 to 1.0156, and washed *thoroughly* between each boiling. "They are then immersed in a solution of the oxymuriate of potash, originally of the strength of 1.0625, and afterwards reduced with 24 times its measure of water. In this preparation they are suffered to remain 12 hours." Dr. Stephenson says, that, for coarse linens, the steep is made by dissolving 1 lb. of oxymuriate of lime in 3 gallons of water, and afterwards diluting with 25 additional gallons. The ordinary specific gravity of the oxymuriate of lime steeps, by Mr. Ramsay, is 1.005. But from these *data* little can be learned; because oxymuriate of lime is always more or less mixed with common muriate of lime, or chloride of calcium, a little of which has a great effect on the hydrometric indications. The period of immersion is 10 or 12 hours. Many bleachers employ gentle and long continued boiling without bucking. The operation of souring was long ago effected by buttermilk, but it is more safely and advantageously performed by the dilute sulphuric acid uniformly combined with the water by much agitation.

Mr. Tennent's ingenious mode of uniting chlorine with pulverulent lime, was one of the greatest improvements in practical bleaching. When this chloride is well prepared and properly applied, it will not injure the most delicate muslin. Magnesia has been suggested as a substitute for lime; but the high price of this alkaline earth must be a bar to its general employment. The muriate of lime solution resulting from the action of unbleached cloth on that of the oxymuriate, if too strong, or too long applied, would weaken the texture of cloth, as Sir *H. Davy* has shown. But the bleacher is on his guard against this accident; and the process of souring, which follows most commonly the oxymuriatic steep, thoroughly removes the adhering particles of lime.

Mr. Parkes informs us, that calicoes for madder work, or resist work, or for the fine pale blue dipping, cannot without injury be bleached with oxymuriate of lime. They require, he says, oxymuriate of potash. I believe this to be a mistake. Test liquors made by dissolving indigo in sulphuric acid, and then diluting the sulphate with water, or with infusion of cochineal, are employed to measure the blanching power of the oxymuriatic or chloridic solutions. But they are all more or less uncertain, from the changeableness of these colouring matters. I have met with indigo of apparently excellent quality, of which four parts were required to saturate the same weight of oxymuriate of lime, as was saturated by three parts of another indigo. Such coloured liquors, however, though they give no absolute measure of chlorine, afford useful means of comparison to the bleacher.

Some writers have recommended lime and sulphuret of lime as detergent substances instead of alkali; but I believe no practical bleacher of respectability would trust to them alone. Lime should always be employed, however, to make the alkalis caustic; in which state their detergent powers are greatly increased.

The coarser kinds of muslin are bleached by steeping, washing, and then boiling them in a weak solution of pot and pearl ashes. They are next washed, and afterwards boiled in soap alone, and then soured in very dilute sulphuric acid. After being washed from the sour, they are boiled with soap, washed, and immersed in the solution of chloride of lime or potash. The boiling in soap, and immersion in the oxymuriate, is repeated, until the muslin is of a pure white colour. It is finally soured and washed in pure spring water. The same series of operations is used in bleaching fine muslins, only soap is used in the boilings commonly to the exclusion of pearl ash. Fast *coloured* cottons are bleached in the following way: — After the starch or dressing is well removed by cold water, they are gently boiled with soap, washed, and immersed in a moderately strong solution of oxymuriate of potash or lime. This process is repeated till the white parts of the cloth are sufficiently pure. They are then soured in dilute sulphuric acid. If these operations be well conducted, the colours, instead of being impaired, will be greatly improved, having acquired a delicacy of tint which no other process can impart.

After immersing cloth or yarn in alkaline ley, if it be exposed to the action of steam heated to 222°, in a strong vessel, it will be in a great measure bleached.

This operation is admirably adapted to the cleansing of hospital linen.

The following is the practice followed by a very skilful bleacher of muslins near Glasgow.

"In fermenting muslin goods, we surround them with our spent leys from the temperature of 100° to 150° F., according to the weather, and allow them to ferment for 36 hours. In boiling 112 lbs. = 112 pieces of yard-wide muslin, we use 6 or 7 lbs. of ashes and 2 lbs. of soft soap, with 360 gallons of water, and allow them to boil for 6 hours; then wash them and boil them again, with 5 lbs. of ashes, and 2 lbs. of soft soap, and allow them to boil 3 hours; then wash them with water, and immerse them into the solution of oxymuriate of lime, at 5 on the test tube, and allow them to remain from 6 to 12 hours; next wash them, and immerse them into diluted sulphuric acid at the specific gravity of 3½ on Twaddle's hydrometer = 1.0175, and allow them, to remain an hour. They are now well washed, and boiled with 2½ lbs. of ashes, and 2lbs. of soap, for half an hour; afterwards washed and immersed into the oxymuriate of lime as before, at the strength of 3 on the test tube, which is stronger than the former, and allowed to remain for 6 hours. They are again washed and immersed into diluted sulphuric acid at the specific gravity of 3 on Twaddle's hydrometer = 1.015. If the goods be strong, they will require another boil, steep, and sour. At any rate, the sulphuric acid is well washed out before they receive the finishing operation with starch.

"With regard to the lime, which some use instead of alkali, immediately after fermenting, the same weight of it is employed as of ashes. The goods are allowed to boil in it for 15 minutes, but not longer, otherwise the lime will injure the fabric."

The alkali may be recovered from the brown lixivia, by evaporating them to dryness and gentle ignition of the residuum. But, in most situations the expense of fuel would exceed the value of the recovered alkali. A simpler mode is to boil the foul lixivium with quicklime, and a little pipe-clay and bullock's blood. After skimming, and subsidence, a tolerably pure ley is obtained.

Under the head of Chlorine, we have described the preparation of this article; and the chief circumstance respecting it to be noticed here is the apparatus, which must be on an extensive scale, and adapted to the purpose of immersing and agitating the goods to be bleached. The process of distillation may be performed in a large leaden alembic, *g g*, Plate I. fig. 1. supported by an iron trevet *f*, in an iron boiler *e*. This is heated by a furnace *b*, of which *a* is the ashhole, *c* the place for introducing the fuel; *d* is the handle of a stopper of burnt clay, for regulating the draught. To the top of the alembic is fitted a leaden cover *i*, which is luted on, and has three perforations; one for the curved glass or leaden funnel *h*, through which the sulphuric acid is to be poured in; one in the centre for the agitator *k*, made of iron coated with lead; and the third for the leaden tube *l*, three inches in diameter internally, through which the gas is conveyed into the tubulated leaden receiver *m*. To prevent the agitator from reaching to the bottom of the alembic, it is furnished with a conical leaden collar, adapted to a conical projection round the hole in the centre of the cover, to which it becomes so closely fitted by means of its rotary motion, as to prevent the escape of the gas. The tube *l* passing through the aperture *m*, to the bottom of the intermediate receiver nearly, which is two-thirds full of water, deposits there the little sulphuric acid that may arise; while the chlorine gas passes through the tube *n* into the wooden condenser *o o*. The agitator *p*, turned by its handle *t*, serves to accelerate the combination of the gas with the alkali, to which the horizontal pieces *q q*, projecting from the inside, likewise contribute. The cover of this receiver has a sloping groove *r*, to fit close on its edge, which is bevelled on each side; and a cock *s* serves to draw off the liquor.

Mr. Tennent's chloride of lime has nearly superseded that plan.

The rags or other materials for making paper may be bleached in a similar manner; but it is best to reduce them first to the state of pulp, as then the acid acts more uniformly upon the whole substance.

For bleaching old paper: Boil your printed paper for an instant in a solution of caustic soda: that from kelp may be used. Steep it in soap-suds, and then wash it; after which it may be reduced to pulp. The soap may be omitted without much inconvenience.—For old written paper to be worked up again: Steep it in water acidulated with sulphuric acid, and then wash it well before it is taken to the mill. If the water be heated it will be more effectual.—To bleach printed paper, without destroying its texture: Steep the leaves in a caustic solution of soda, either hot or cold, and then in a solution of soap. Arrange them alternately between cloths, as paper-makers do thin sheets of paper when delivered from the form, and subject them to the press. If one operation do not render them sufficiently white, it may be repeated as often as necessary.—To bleach old written paper, without destroying its texture: Steep the paper in water acidulated with sulphuric acid, either hot or cold, and then in a solution of oxygenated muriatic acid; after which immerse it in water, that none of the acid may remain behind. This paper, when pressed and dried, will be fit for use as before.

BLEACHING POWDER, or SALT. Chloride of lime, which see. It is also called oxymuriate of lime.

BLEND. An ore of zinc.

BLOOD. The fluid which first presents itself to observation, when the parts of living animals are divided or destroyed, is the blood, which circulates with considerable velocity through vessels, called veins and arteries, distributed into every part of the system.

Recent blood is uniformly fluid, and of a saline taste. Under the microscope, it appears to be composed of a prodigious number of red globules, swimming in a transparent fluid. After standing for a short time, its parts separate into a thick red matter, or crassamentum, and a fluid called serum. If it be agitated till cold, it continues fluid; but a consistent polypous matter adheres to the stirrer, which by repeated ablutions with water becomes white, and has a fibrous appearance: the crassamentum becomes white and fibrous by the same treatment. If blood be received from the vein into warm water, a similar filamentous matter subsides, while the other parts are dissolved. Alkalis prevent the blood from coagulating; acids, on the contrary, accelerate that effect. In the latter case, the fluid is found to contain neutral salts, consisting of the acid itself, united with soda, which consequently must exist in the blood, probably in a disengaged state. Alcohol coagulates blood. On the water bath, blood affords an aqueous fluid, neither acid nor alkaline, but of a faint smell, and easily becoming putrid. A stronger heat gradually dries it, and at the same time reduces it to a mass of about one-eighth of its original weight.

Blood usually consists of about 3 parts serum to 1 of cruor. The serum is of a pale greenish-yellow colour. Its specific gravity is about 1.029, while that of blood itself is 1.053. It changes syrup of violets to a green, from its containing free soda. At 156° serum coagulates and resembles boiled white of egg. When this coagulated albumen is squeezed, a muddy fluid exudes, which has been called the serosity. According to Berzelius, 1000 parts of the serum of bullock's blood consist of 905 water, 79.99 albumen, 6.175 lactate of soda and extractive matter, 2.565 muriates of soda and potash, 1.52 soda and animal matter, and 4.75 loss. 1000 parts of serum of human blood consist, by the same chemist, of 905 water, 80 albumen, 6 muriates of potash and soda, 4 lactate of soda with animal matter, and 4.1 of soda, and phosphate of soda with animal matter. There is no gelatin in serum.

The cruor has a specific gravity of about 1.245. By making a stream of water flow upon it till the water runs off colourless, it is separated into insoluble fibrin, and the soluble colouring matter. A little albumen has also been found in cruor. The proportions of the former two are, 64 colouring matter, and 36 fibrin in 100. To obtain the colouring matter pure, we mix the cruor with 4 parts of oil of vitriol previously diluted with 8 parts of water, and expose the mixture to a heat of about 160° for 5 or 6 hours. Filter the liquid while hot, and wash the residue with a few ounces of hot water. Evaporate the liquid to one-half, and add ammonia, till the acid be almost, but not entirely saturated. The colouring matter falls. Decant the supernatant liquid, filter and wash the residuum, from the whole of the sulphate of ammonia. When it is well drained, remove it with a platina blade, and dry it in a capsule.

When solid, it appears of a black colour, but becomes wine-red by diffusion through water, in which, however, it is not soluble. It has neither taste nor smell. Alcohol and ether convert it into an unpleasant smelling kind of adipocere. It is soluble both in alkalis and acids. It approaches to fibrin in its constitution, and contains iron in a peculiar state, ⅓ of a per cent. of the oxide of which may be extracted from it by calcination. The incinerated colouring matter weighs 1-80th of the whole; and these ashes consist of 50 oxide of iron, 7.5 subphosphate of iron, 6 phosphate of lime, with traces of magnesia, 20 pure lime, 16.5 carbonic acid and loss; or the two latter ingredients may be reckoned 32 carbonate of lime. Berzelius imagines that none of these bodies existed in the colouring matter, but only their bases iron, phosphorus, calcium, carbon, &c. and that they were formed during the incineration. From the albumen of blood, the same proportion of ashes may be obtained, but no iron.

No good explanation has yet been given of the change of colour which blood undergoes from exposure to oxygen, and other gases. Under the exhausted receiver, carbonic acid gas is disengaged from it. The blood of the fœtus is darker coloured than that of the adult; it has no fibrin, and no phosphoric acid. The buffy coat of inflamed blood is fibrin; from which the colouring matter has precipitated by the greater liquidity or slowness of coagulation produced by the disease. The serum of such blood does not yield consistent albumen by heat. In diabetes mellitus, when the urine of the patient is loaded with sugar, the serum of the blood assumes the appearance of whey, according to Dr. Rollo and Dobson; but Dr. Wollaston has proved that it contains no sugar.

Dr. Carbonel of Barcelona has employed serum of blood on an extensive scale in painting. Mixed with powdered quicklime or slaked lime, to a proper consistence, it is easily applied on wood, to which it thus gives a coating of a stone colour, that dries quickly, without any bad smell, and resists the action of sun and rain. The wood should be first covered with a coating of plaster, the composition must be mixed as it is used, and the serum must not be stale. It may be used too as a cement for water-pipes, and for stones in building under water.

BLOODSTONE. See CALCEDONY.

BLOWPIPE. This simple instrument will be described under the article LABORATORY.

We shall here present our readers first with an abstract of Assessor Gahn's late valuable treatise on the *common* blowpipe, and shall afterwards give an account of Dr. Clarke's very interesting experiments with the *oxyhydrogen* blowpipe.

The substance to be submitted to the action of the blowpipe must be placed on a piece of charcoal, or in a small spoon of platina, gold, or silver; or, according to Saussure, a plate of cyanite may sometimes be used. Charcoal from the pine is to be preferred, which should be well ignited and dried that it may not crack. The sides, not the ends, of the fibres must be used; otherwise the substance to be fused spreads about, and a round bead will not be formed. A small hole is to be made in the charcoal, which is best done by a slip of plate iron bent longitudinally. Into this hole the substance to be examined must be put in very small quantity; if a very intense heat is to be used, it should not exceed the size of half a peppercorn.

The metallic spoons are used when the substance to be examined is intended to be exposed to the action of heat only, and might undergo some change by immediate contact with the charcoal. When the spoon is used, the flame of the blowpipe should be directed to that part of it which contains the substance under examination, and not be immediately applied to the substance itself. The handle of the spoon may be inserted into a piece of charcoal: and if a very intense heat is required, the bowl of the spoon may be adapted to a hole in the charcoal. Small portions may be taken up by platina forceps. Salts and volatile substances are to be heated in a glass tube closed at one end, and enlarged according to circumstances, so as to form a small matrass.

When the alteration which the substance undergoes by the mere action of heat has been observed, it will be necessary to examine what further change takes place when it is melted with various fluxes, and how far it is capable of reduction to the metallic state.

These fluxes are—

1. Microcosmic salt; a compound of phosphoric acid, soda, and ammonia.

2. Subcarbonate of soda, which must be free from all impurity, and especially from sulphuric acid, as this will be decomposed, and sulphuret of soda will be formed, which will dissolve the metals we wish to reduce, and produce a bead of coloured glass with substances that would otherwise give a colourless one.

3. Borax, which should be first freed from its water of crystallization.

These are kept powdered in small phials; and when used, a sufficient quantity may be taken up by the moistened point of a knife: the moisture causes the particles to cohere, and prevents their being blown away when placed on the charcoal. The flux must then be melted to a clear bead, and the substance to be examined placed upon it. It is then to be submitted to the action, first of the exterior, and afterwards of the interior flame, and the following circumstances to be carefully observed:—

1. Whether the substance is dissolved; and if so,

2. Whether with, or without effervescence, which would be occasioned by the liberation of carbonic acid, sulphurous acid, oxygen, gaseous oxide of carbon, &c.

3. The transparency and colour of the glass while cooling.

4. The same circumstances after cooling.

5. The nature of the glass formed by the exterior flame, and

6. By the interior flame.

7. The various relations to each of the fluxes.

It must be observed, that soda will not form a bead on charcoal, but with a certain degree of heat will be absorbed. When, therefore, a substance is to be fused with soda, this flux must be added in very small quantities, and a very moderate heat used at first, by which means a combination will take place, and the soda will not be absorbed. If too large a quantity of soda has been added at first, and it has consequently been absorbed, a more intense heat will cause it to return to the surface of the charcoal, and it will then enter into combination.

Some minerals combine readily with only very small portions of soda, but melt with difficulty if more be added, and are absolutely infusible with a larger quantity: and when the substance has no affinity for this flux, it is absorbed by the charcoal, and no combination ensues.

When the mineral or the soda contains sulphur or sulphuric acid, the glass acquires a deep yellow colour, which by the light of a lamp appears red, and as if produced by copper.

If the glass bead becomes opaque as it cools, so as to render the colour indistinct, it should be broken, and a part of it mixed with more of the flux, until the colour becomes more pure and distinct. To render the colour more perceptible, the bead may be either compressed before it cools, or drawn out to a thread.

When it is intended to oxidate more highly a metallic oxide contained in a vitrified compound with any of the fluxes, the glass is first heated by a strong flame, and when melted is to be gradually withdrawn from the point of the blue flame. This operation may be repeated several times, permitting the glass sometimes to cool, and using a jet of large aperture with the blowpipe.

The *reduction* of metals is effected in the following manner: The glass bead, formed after the manner already pointed out, is to be kept in a state of fusion on the charcoal as long as it remains on the surface, and is not absorbed, that the metallic particles may collect themselves into a globule. It is then to be fused with an additional quantity of soda, which will be absorbed by the charcoal, and the spot where the absorption has taken place is to be strongly ignited by a tube with a small aperture. By continuing this ignition, the portion of metal which was not previously reduced will now be brought to a metallic state; and the process may be assisted by placing the bead in a smoky flame, so as to cover it with soot that is not easily blown off.

The greatest part of the beads which contain metals are frequently covered with a metallic splendour, which is most easily produced by a gentle, fluttering, smoky flame, when the more intense heat has ceased. With a moderate heat the metallic surface remains; and by a little practice it may generally be known whether the substance under examination contains a metal or not. But it must be observed, that the glass of borax sometimes assumes externally a metallic splendour.

When the charcoal is cold, that part impregnated with the fused mass should be taken out with a knife, and ground with distilled water in a crystal, or, what is much better, an agate mortar. The soda will be dissolved; the charcoal will float, and may be poured off; and the metallic particles will remain in the water, and may be examined. In this manner most of the metals may be reduced.

Relations of the Earths and Metallic Oxides before the Blowpipe.

I. THE EARTHS.

Barytes, when containing water, melts and spreads on the charcoal. Combined with sulphuric acid, it is converted, in the *interior* flame, into a sulphuret, and is absorbed by the charcoal, with effervescence, which continues as long as it is exposed to the action of the instrument.

Strontites. If combined with carbonic acid, and held in small thin plates with platina forceps in the *interior* flame, the carbonic acid is driven off; and on the side of the plate farthest from the lamp, a red flame is seen sometimes edged with green, and scarcely perceptible but by the flame of a lamp. Sulphate of strontites is reduced in the *interior* flame to a sulphuret. Dissolve this in a drop of muriatic acid, add a drop of alcohol, and dip a small bit of stick in the solution; it will burn with a fine red flame.

Lime. The carbonate is easily rendered caustic by heat; it evolves heat on being moistened, and is afterwards infusible before the blowpipe. The sulphate is easily reduced to sulphuret, and possesses, besides, the property of combining with fluor at a moderate heat, forming a clear glass. The fluor should be rather in excess.

Magnesia produces, like the strontites, an intense brightness in the flame of the blowpipe. A drop of solution of cobalt being added to it, and it being then dried and strongly ignited, a faint reddish colour like flesh is produced, which, however, is scarcely visible by the light of a lamp. And magnesia may by this process be detected in compound bodies, if they do not contain much metallic matter, or a proportion of alumina exceeding the magnesia. Some inference as to the quantity of the magnesia may be drawn from the intensity of the colour produced.

All these alkaline earths, when pure, are readily fusible in combination with the fluxes into a clear, colourless glass, without effervescence; but on adding a further quantity of the earth, the glass becomes opaque.

Alumina combines more slowly with the fluxes than the preceding earths do, and forms a clear glass, which does not become opaque. But the most striking character of alumina is the bright blue colour it acquires from the addition of a drop of nitrate of cobalt, after having been dried and ignited for some time. And its presence may be detected in this manner in compound minerals, where the metallic substances are not in great proportion, or the quantity of magnesia large. Alumina may be thus detected in the agalmatolite.

II. THE METALLIC OXIDES.

Arsenic flies off accompanied by its characteristic smell, resembling garlic. When larger pieces of white arsenic are heated on a piece of ignited charcoal, no smell is perceived. To produce this effect the white oxide must be reduced, by being mixed with powdered charcoal. If arsenic is held in solution, it may be discovered by dipping into the solution a piece of pure and well burned charcoal, which is afterwards to be dried and ignited.

Chrome. Its green oxide, the form in which it most commonly occurs, and to which it is reduced by heating in the common air, exhibits the following properties: It is fusible with *microcosmic salt*, in the *interior* flame, into a glass which, at the instant of its removal from the flame, is of a violet hue, approaching more to the dark blue or red, according to the proportion of chrome. After cooling, the glass is bluish-green, but less blue than the copper glass. In the *exterior* flame the colour becomes brighter, and less blue, than the former. With *borax* it forms a bright yellowish, or yellow-red glass, in the *exterior* flame; and in the *interior* flame, this becomes darker and greener, or bluish-green. The reduction with soda has not been examined.

Molybdic acid melts by itself upon the charcoal with ebullition, and is absorbed. In a platina spoon it emits white fumes, and is reduced in the *interior* flame to molybdous acid, which is blue; but in the *exterior* flame it is again oxidated, and becomes white. With *microcosmic salt*, in the *exterior* flame, a small proportion of the acid gives a green glass, which, by gradual additions of the acid, passes through yellow-green to reddish, brownish, and hyacinth brown, with a slight tinge of green. In the *interior* flame the colour passes from yellow-green, through yellow-brown and brown-red, to black; and if the proportion of acid be large, it acquires a metallic lustre, like the sulphuret, which sometimes remains after the glass has cooled. Molybdic acid is but little dissolved by *borax*.

In the *exterior* flame the glass acquires a grey-yellow colour. In the *interior* flame, a quantity of black particles is precipitated from the clear glass, and leaves it almost colourless when the quantity of molybdenum is small, and blackish when the proportion is larger. If to a glass formed of this acid and microcosmic salt a little borax be added, and the mixture fused in the *exterior* flame, the colour becomes instantly reddish-brown; in the *interior* flame the black particles are also separated, but in smaller quantity. By long continued heat the colour of the glass is diminished, and it appears yellower by the light of a lamp than by daylight. This acid is not reduced by soda in the interior flame.

Tungstic acid becomes upon the charcoal at first brownish-yellow, is then reduced to a brown oxide, and lastly becomes black without melting or smoking. With *microcosmic salt* it forms in the *interior* flame a pure blue glass, without any violet tinge; in the *exterior* flame this colour disappears, and reappears again in the *interior.* With *borax*, in the *internal* flame, and in small proportions, it forms a colourless glass, which, by increasing the proportion of the acid, becomes dirty grey, and then reddish. By long exposure to the *external* flame it becomes transparent, but as it cools it becomes muddy, whitish, and changeable into red when seen by day-light. It is not reduced.

Oxide of Tantalum undergoes no change by itself, but is readily fused with *microcosmic salt* and with *borax*, into a clear colourless glass, from which the oxide may be precipitated by heating and cooling it alternately. The glass then becomes opaque, and the oxide is not reduced.

Oxide of Titanium becomes yellowish when ignited in a spoon, and upon charcoal dark brown. With *microcosmic salt* it gives in the *interior* flame a fine violet-coloured glass, with more of blue than that from manganese. In the *exterior* flame this colour disappears. With borax it gives a dirty hyacinth colour. Its combinations with soda have not been examined.

Oxide of Cerium becomes red-brown when ignited. When the proportion is small it forms with the fluxes a clear colourless glass, which, by increasing the proportion of oxide, becomes yellowish-green while hot. With *microcosmic salt*, if heated a long time in the *internal* flame, it gives a clear colourless glass. With *borax*, under similar circumstances, it gives a faint yellow-green glass while warm, but colourless when cold. Exposed again for some time to the *external* flame, it becomes reddish-yellow; which colour it partly retains when cold. If two transparent beads of the compound with microcosmic salt and with borax be fused together, the triple compound becomes opaque and white. Flies off by reduction.

Oxide of Uranium. The yellow oxide by ignition becomes green or greenish-brown. With *microcosmic salt* in the *interior* flame it forms a clear yellow glass, the colour of which becomes more intense when cold. If long exposed to the *exterior* flame, and frequently cooled, it gives a pale yellowish red-brown glass, which becomes greenish as it cools. With *borax* in the *interior* flame, a clear, colourless, or faintly green glass, is formed, containing black particles, which appear to be the metal in its lowest state of oxidation. In the *exterior* flame this black matter is dissolved, if the quantity be not too great, and the glass becomes bright yellowish-green, and after further oxidation yellowish-brown. If brought again into the *interior* flame, the colour gradually changes to green, and the black matter is again precipitated, but no further reduction takes place.

Oxide of Manganese gives with *microcosmic salt* in the *exterior* flame a fine amethyst colour, which disappears in the *interior* flame. With *borax* it gives a yellowish hyacinth red glass.

When the manganese, from its combination with iron, or any other cause, does not produce a sufficiently intense colour in the glass, a little nitre may be added to it while in a state of fusion, and the glass then becomes dark violet while hot, and reddish-violet when cool: is not reduced.

Oxide of Tellurium, when gently heated, becomes first yellow, then light red, and afterwards black. It melts and is absorbed by the charcoal, and is reduced with a slight detonation, a greenish flame, and a smell of horse-radish. *Microcosmic salt* dissolves it without being coloured.

Oxide of Antimony is partly reduced in the *exterior* flame, and spreads a white smoke on the charcoal. In the *interior* flame it is readily reduced by itself, and with soda. With microcosmic salt and with borax it forms a hyacinth-coloured glass. Metallic antimony, when ignited on charcoal, and remaining untouched, becomes covered with radiating acicular crystals of white oxide. Sulphuret of antimony melts on charcoal, and is absorbed.

Oxide of Bismuth melts readily in a spoon to a brown glass, which becomes brighter as it cools. With *microcosmic salt* it forms a grey-yellow glass, which loses its transparency, and becomes pale, when cool. Add a further proportion of oxide, and it becomes opaque. With *borax* it forms a grey glass, which decrepitates in the *interior* flame, and the metal is reduced and volatilized. It is most readily reduced by itself on charcoal.

Oxide of Zinc becomes yellow when heated, but whitens as it cools. A small proportion forms with *microcosmic salt* and with *borax* a clear glass, which becomes opaque on increasing the quantity of oxide. A drop of nitrate of cobalt being added to the oxide, and dried and ignited, it becomes green. With *soda* in the *interior* flame it is reduced, and burns with its characteristic flame, depositing its oxide upon the charcoal. By this process zinc may be easily detected even in the automolite. Mixed with oxide of copper, and reduced, the zinc will be fixed, and brass be obtained. But one of the most unequivocal characters of the oxide of zinc is to dissolve it in vinegar, evaporate the solution to dryness, and expose it to the flame of a lamp, when it will burn with its peculiar flame.

Oxide of Iron produces with *microcosmic salt* or *borax* in the *exterior* flame, when cold, a yellowish glass, which is blood-red while hot. The protoxide forms with these fluxes a green glass, which, by increasing the proportion of the metal, passes through bottle-green to black and opaque. The glass from the oxide becomes green in the *interior* flame, and is reduced to protoxide, and becomes attractible by the magnet. When placed on the wick of a candle, it burns with the crackling noise peculiar to iron.

Oxide of Cobalt becomes black in the *exterior*, and grey in the *interior* flame. A small proportion forms with *microcosmic salt* and with *borax* a blue glass, that with borax being the deepest. By transmitted light the glass is reddish. By farther additions of the oxide it passes through dark blue to black. The metal may be precipitated from the dark blue glass by inserting a steel wire into the mass while in fusion. It is malleable if the oxide has been free from arsenic, and may be collected by the magnet; and is distinguished from iron by the absence of any crackling sound when placed on the wick of a candle.

Oxide of Nickel becomes black at the extremity of the *exterior* flame, and in the *interior* greenish-grey. It is dissolved readily, and in large quantity, by *microcosmic salt*. The glass, while hot, is a dirty dark red, which becomes paler and yellowish as it cools. After the glass has cooled, it requires a large addition of the oxide to produce a distinct change of colour. It is nearly the same in the *exterior* and *interior* flame, being slightly reddish in the latter. Nitre added to the bead makes it froth, and it becomes red-brown at first, and afterwards paler. It is easily fusible with *borax*, and the colour resembles the preceding. When this glass is long exposed to a high degree of heat in the *interior* flame, it passes from reddish to blackish and opaque; then blackish-grey, and translucent; then paler reddish-grey, and clearer; and, lastly, transparent; and the metal is precipitated in small white metallic globules. The red colour seems here to be produced by the entire fusion or solution of the oxide, the black by incipient reduction, and the grey by the minute metallic particles before they combine and form small globules. When a little soda is added to the glass formed with borax, the reduction is more easily effected, and the metal collects itself into one single globule. When this oxide contains iron, the glass retains its own colour while hot, but assumes that of the iron as it cools.

Oxide of Tin in form of hydrate, and in its highest degree of purity, becomes yellow when heated, then red, and when approaching to ignition, black. If iron or lead be mixed with it, the colour is dark-brown when heated. These colours become yellowish as the substance cools. Upon charcoal in the *interior* flame it becomes and continues white; and, if originally white and free from water, it undergoes no change of colour by heating. It is very easily reduced without addition, but the reduction is promoted by adding a drop of solution of soda or potash.

Oxide of Lead melts, and is very quickly reduced, either without any addition, or when fused with microcosmic salt or borax. The glass not reduced is black.

Oxide of Copper is not altered by the exterior flame, but becomes protoxide in the interior. With both *microcosmic salt* and *borax* it forms a yellow-green glass while hot, but which becomes blue-green as it cools. When strongly heated in the *interior* flame, it loses its colour, and the metal is reduced. If the quantity of oxide is so small that the green colour is not perceptible, its presence may be detected by the addition of a little tin, which occasions a reduction of the oxide to protoxide, and produces an opaque red glass. If the oxide has been fused with borax, this colour is longer preserved; but if with microcosmic salt, it soon disappears by a continuance of heat.

The copper may also be precipitated upon iron, but the glass must be first saturated with iron. Alkalis or lime promote this precipitation. If the glass containing copper be exposed to a smoky flame, the copper is superficially reduced, and the glass covered while hot with an iridescent pellicle, which is not always permanent after cooling. It is very easily reduced by soda. Salts of copper, when heated before the blowpipe, give a fine green flame.

Oxide of Mercury before the blowpipe becomes black, and is entirely volatilized. In this manner its adulteration may be discovered.

The other metals may be reduced by themselves, and may be known by their own peculiar characters.—*See Berzelius on the Blowpipe, as translated by Mr. Children.*

The following valuable synoptic Table of the principal Characters of the Earths and Metallic Oxides, before the Blowpipe, is extracted from that valuable work.

Abbreviations.—O. F. oxidating flame; R. F. reducing flame; = parts, equal parts of the assay and flux; N. C. nitrate of cobalt; Fl. flaming; C. under the column of either of the fluxes, means that the support is charcoal; P. F. platinum foil; P. W. platinum wire; a brace { refers to the substances in the first column only, and includes all those which are contained in the space it comprehends.

Assay.	Heated alone on	
	Platina.	Charcoal.
Alkalis		
Baryta	Infusible.	Infusible.
Hydrate	Bubbles up and fuses.	Is absorbed.
Carbonate	Fuses readily into a clear-glass; enamel white on cooling.	Becomes caustic, and is absorbed.
Strontita	Infusible.	Infusible.
Hydrate	Like Baryta.	
Carbonate	Fuses with moderate heat at the surface, great brilliancy; tinges strong R.F. red; becomes alkaline.	
Lime	No change.	
Carbonate	Becomes caustic and alkaline; emits brilliant white light.	
Magnesia	No change.	No change.
Alumina	No change.	No change.
Glucina	No change.	No change.
Yttria	No change.	No change.
Zirconia	Infusible; emits intense light.	Infusible; emits intense light.
Silica	No change.	No change.
Molybdic Acid	F. fumes and fuses; brown yellow on cooling; in R.F. blue; intense heat, brown.	Fuses, and is absorbed, and partly reduced.
Tungstic Acid	R.F. blackens, but not reduced.	The same.
Oxide of Chrome	No change.	The same.
Antimony		Fuses readily; white fumes, which condense into pearly crystals.
Oxide of Antimony	Fuses readily, and sublimes, in white fumes; precipitated oxide, burns like tinder into antimonious acid.	Fuses readily, and reduces; colours the flame greenish.
Antimonious Acid		Does not fuse, nor reduce; gives a bright light.
Antimonic Acid		Whitens; is changed to antimonious acid.
Oxide of Tellurium	F. fuses and fumes.	Fuses, effervesces, and reduces.
Oxide of Columbium	No change.	The same.
Oxide of Titanium	No change.	The same.
Oxides of Uranium		Peroxide becomes protoxide; blackens, but does not fuse.
Oxides of Cerium	Protoxide becomes peroxide.	Peroxide does not alter.
Oxide of Manganese		Not fused; becomes brown in a strong heat.
Oxide of Zinc	Yellow while hot; white when cold; does not fuse, but gives out great light when very hot, and white fumes, which condense like wool.	

ASSAY.	HEATED ALONE ON PLATINA.	HEATED ALONE ON CHARCOAL.
Oxide of Cadmium....	F. no change.	Soon dissipates; leaves a red or orange-yellow powder on the charcoal.
Oxide of Iron.........	O.F. no change.	R. F. blackens, and becomes magnetic.
Oxide of Cobalt.......	No change.	The same.
Oxide of Nickel.......	No change.	The same.
Bismuth.............		Flies off in fumes, and leaves a mark with red, or orange edges, which may be dissipated in R. F. without giving colour to the flame.
Oxide of Bismuth...	F. fuses readily, mass dark brown, yellowish on cooling. In very intense heat reduces, and perforates the foil.	Instantly reduced
Oxides of Tin	Protoxide takes fire, and burns like tinder into peroxide.	R.F. peroxide does not fuse, but reduces in a strong prolonged heat.
Oxide of Lead........	Minium becomes black while hot; at incipient redness, changes to yellow oxide, fusible into orange-coloured glass.	Orange glass reduces into a globule of lead.
Oxide of Copper.......		O. F. black globule; flows over the charcoal, under surface reduces. R. F. reduces; with strong heat gives a bead of metal.
Mercury		
Oxide of Silver......	Instantly reduced.	Instantly reduced.
Gold		
Platina		
Iridium		
Rhodium		
Palladium		

ASSAY.	HEATED WITH FLUXES. SODA.	BORAX.	SALT OF PHOSPHORUS.
Alkalis			
Baryta	Fuse and are absorbed by the charcoal.	Fuse readily with effervescence into a clear glass, which becomes opaque by Fl.	As with borax, but foam and intumesce; end in a clear glass.
Hydrate			
Carbonate			
Strontita	No action on caustic strontita.	Like Baryta.	Ditto.
Hydrate			
Carbonate	= parts, fuses into a clear glass, becomes milky on cooling: in strong heat, bubbles, and absorbed by the charcoal.		
Lime	No sensible quantity dissolved.	Clear glass: opaque by Fl.	Fuses in large quantity; clear glass.
Carbonate		Fuses with effervescence; with more carbonate clear glass; crystallizes on cooling.	Fuses with effervescence.

ASSAY.	HEATED WITH FLUXES.		
	SODA.	BORAX.	SALT OF PHOSPHORUS.
Magnesia	No action.	Like lime.	Fuses readily; clear glass; saturated with magnesia, opaque on cooling.
Alumina	Swells up; forms an infusible compound.	Fuses slowly; permanently clear glass.	Permanently clear glass.
Glucina	No action.	Clear glass, with a large proportion of the assay; opaque by Fl.	As with borax.
Yttria	Like Glucina.	Like Glucina.	Like Glucina.
Zirconia	Similar to Glucina.	Like Glucina.	Like Glucina, but dissolves more difficultly.
Silica	Fuses with brisk effervescence; clear glass.	Fuses veryslowly; permanently clear glass.	Very small portion dissolves; clear glass.
Molybdic Acid	P. W. effervesces; clear glass; becomes milky on cooling. C. fuses, absorbed and reduced.	P. W. clear glass in O.F. C. and in R. F. glass becomes dirty brown, but not opaque.	P. W. and in O. F. greenish glass while hot; colourless, cold. In R. F. becomes opaque; dull blue while hot; clear and fine green on cooling. C. same phenomena.
Tungstic Acid	P. W. dark yellow glass, crystallizes on cooling; opaque, white or yellowish. C. and R. F. reduced.	P. W. and O. F. clear glass; not opaque by Fl. R. F. glass becomes yellow.	O. F. yellowish glass. R. F. fine blue glass.
Oxide of Chrome	P.W. and O.F. dark orange glass; opaque and yellow on cooling. R. F. opaque; glass green on cooling. C. absorbed, but not reduced.	C. fuses difficultly; glass emerald green; on P. W. and O. F. the colour flies, and glass becomes brown yellow; on cooling, assumes a faint green tinge.	Green glass in both flames.
Antimony			
Oxide of Antimony	P.W. fuses; clear colourless glass becomes white on cooling. C. is reduced.	C. dissolves in large quantity; glass yellowish, hot; almost colourless, cold; if saturated, part reduced and sublimed; strong R.F. the glass becomes opaque and greyish.	P.W. and O.F. glass, yellowish hot; colour flies on cooling.
Antimonious Acid			
Antimonic Acid			
Oxide of Tellurium	P.W. colourless glass; white on cooling. C. reduced.	P. W. clear colourless glass; white on cooling. C. becomes grey and opaque.	The same.
Oxide of Columbium	Combines with effervescence, but not fused or reduced.	Colourless, clear glass, becomes opaque by Fl.	Fuses easily; glass permanently clear.
Oxide of Titanium	Fuses into a clear dark yellow glass; white or grey-white on cooling, and crystallizes with evolution of great heat. C. not reducible.	P. W. fuses easily; glass, colourless; becomes milk-white by Fl. R. F. glass assumes a dark amethyst colour, but transparent.	O.F. clear colourless glass. R.F. and on C. glass yellowish hot; on cooling, first red, then very fine bluish violet.

ASSAY.	HEATED WITH FLUXES.		
	SODA.	BORAX.	SALT OF PHOSPHORUS.
		In large quantity, on C. and R. F. glass, dull yellow; when cold, deep blue.	
Oxides of Uranium	C. brown yellow; not fused.	P. W. dark yellow glass; in R. F. becomes dirty green.	P. W. and O. F. clear yellow glass; cold, straw-yellow, slightly green. C. and R.F. fine green glass.
Oxides of Cerium	C. not fused, soda absorbed; white or grey-white protoxide remains on the surface.	O.F. fine red, or deep orange yellow glass; colour flies on cooling; cold, yellowish tint. Enamel white by Fl. In R. F. loses its colour.	O. F. fine red glass; colourless when cold, and quite limpid.
Oxide of Manganese	P.F. fuses, green glass, clear; cold, bluish green. C. not reduced.	O. F. clear, amethyst colour, glass; colour flies in R. F.	The same, but colour not so deep. In fusion in O. F. boils, and gives off gas; in R.F. fuses quietly.
Oxide of Zinc	C. not fused, but reduced with flame; white fumes, which cover the charcoal.	O.F. fuses easily, clear glass becomes milky by Fl.	Nearly the same.
Oxide of Cadmium	P.W. not fused. C. reduced, sublimes, and leaves a circular yellowish mark.	P.W. yellowish glass, colour flies on cooling; on C. glass bubbles, Cadmium reduced, sublimes and leaves yellow oxide.	Dissolves in large quantity, clear glass; on cooling, milk white.
Oxide of Iron	C. absorbed and reduced; not fused.	O.F. dull red glass, becomes clear and yellowish or colourless by cooling. C. and R. F. bottle-green glass, or bluish green.	Similar to borax.
Oxide of Cobalt	P. W. pale red, by transmitted light; grey, cold.	Fuses readily, deep blue glass.	The same, the colour appears violet by candle light.
Oxide of Nickel	C. absorbed and reduced; not fused.	O. F. orange yellow; or reddish glass; becomes yellow, or nearly colourless, on cooling.	As with borax, but the colour flies almost wholly on cooling.
Bismuth *Oxide of Bismuth*		O. F. colourless glass. R. F. partly reduced, muddy greyish glass.	O. F. yellowish-brown glass, hot; colourless, but not quite clear, cold. R. F. clear and colourless glass, hot; opaque and greyish black, cold.
Oxides of Tin	P.W. effervesces, tumified, infusible mass. C. readily reduced.	Fuses with great difficulty; permanently clear glass.	As with borax.

Assay.	Heated with Fluxes.		Salt of Phosphorus.
	Soda.	Borax.	
Oxide of Lead	P.W. clear glass; becomes yellowish and opaque on cooling. C. instantly reduced.	P.W. clear glass; yellow, hot; on cooling, colourless. C. flows over the surface and reduces.	Clear colourless glass.
Oxide of Copper	P.W. fine green glass, hot; on cooling, colourless and opaque. C. absorbed and reduced.	O.F. fine green glass, which in R.F. becomes colourless, hot; but cinnabar-red, and opaque when solid.	O. F. similar to borax. R. F. glass, usually red, opaque, and like an enamel.
Mercury			
Oxide of Silver		O.F. glass becomes milky, or opaline, on cooling. R.F. greyish.	O. F. yellowish glass viewed by transmitted light by day, by candlelight reddish. R. F. greyish.
Gold			
Platina			
Iridium			
Rhodium			
Palladium			

Assay.	With other Reagents.	Remarks.
Alkalis		*The alkalis* are not readily distinguishable by the blowpipe. *Lithia* leaves a dull yellow stain, when heated to redness on platina foil. *Ammonia* may be known by heating the assay with soda; it gives off a pungent vapour, which turns the yellow colour of moistened turmeric paper brown.
Baryta	N. C. a globule of different shades of red; colour flies on cooling.	
Hydrate		
Carbonate		
Strontita	N. C. exhibit a black, or greyish-black colour; do not fuse.	
Hydrate		
Carbonate		
Lime	N. C. black or dark grey mass, infusible.	
Carbonate		
Magnesia	N. C. flesh colour when quite cold.	
Alumina	N. C. fine blue glass, with strong heat when cold.	The blue colour is only distinctly seen by daylight.
Glucina	N. C. black or dark grey mass.	
Yttria		
Zirconia		
Silica	N. C. blue glass when perfectly fused.	The part not perfectly fused with nitrate of cobalt has a reddish-blue disagreeable colour.
Molybdic Acid		In the inclined glass tube, fuses, gives off vapour, which condenses partly on the tube as a white powder, partly on the assay in brilliant pale yellow crystals.

Assay.	With other Reagents.	Remarks.
Tungstic Acid........		If tungstic acid contain iron, the glass with salt of phosphorus is blood-red in R. F. Tin makes it green or blue.
Oxide of Chrome		
Antimony...........		Antimony does not sublime at the fusing point of glass. On charcoal when red, ignition continues spontaneously. In a tube open at both ends, it gives off white fumes.
Oxide of Antimony		The oxide and acids of antimony behave alike with the fluxes.
Antimonious Acid.		
Antimonic Acid..		
Oxide of Tellurium...		Metallic tellurium heated in a glass matrass, first gives off vapour, and then a grey metallic sublimate of tellurium. In a tube open at both ends, emits abundant fumes which condense in a white fusible powder.
Oxide of Columbium		
Oxide of Titanium....	N. C. black or greyish black.	For the rest of the phenomena, see the original work.
Oxides of Uranium		
Oxides of Cerium		
Oxide of Manganese...		A very minute portion of manganese gives a green glass with soda.
Oxide of Zinc		
Oxide of Cadmium		
Oxide of Iron........		The reduction of iron from the peroxide to protoxide is facilitated by tin.
Oxide of Cobalt......	With subcarbonate of potassa, black glass when cold.	
Oxide of Nickel		
Bismuth..........		In a glass matrass does not sublime at the fusing point of glass. In an open tube scarcely gives off any fumes; the metal becomes covered with a dull brown fused oxide, of a slight yellowish tint, when cold.
Oxide of Bismuth		
Oxides of Tin		
Oxide of Lead		
Oxide of Copper		
Mercury...........		All the compounds of mercury are volatile; mixed with tin or iron filings, and heated in a glass tube, metallic mercury distils over.
Oxide of Silver		
Gold..............		These metals have no action on the fluxes, which can only serve to detect the foreign metals they may be combined with. They are best examined by cupellation with lead.
Platina...........		
Iridium...........		
Rhodium..........		
Palladium.........		

Under the mineral species and calculus, their habitudes with the blowpipe are given.

Dr. Robert Hare, Professor of Natural Philosophy in the University of Philadelphia, published, in the first volume of Bruce's Mineralogical Journal, an account of very intense degrees of heat, which he had produced and directed on different bodies, by a jet of flame, consisting of hydrogen and oxygen gases, in the proportion requisite for forming water. The gases were discharged from separate gasometers, and were brought in contact only at a common orifice or nozzle of small diameter, in which their two tubes terminated.

In the first number of the Journal of Science and Arts, is a description of a blowpipe contrived by Mr. Brooke, and executed by Mr. Newmann, consisting of a strong iron box, with a blowpipe nozzle and stop-cock, for regulating the emission of air, which had been previously condensed into the box, by means of a syringe screwed into its top.

John George Children, Esq. first proposed to Sir H. Davy the application of Newmann's apparatus to the mixture of oxygen and hydrogen, immediately after Sir H. had discovered that the explosion from oxygen and hydrogen would not communicate through very small apertures; and he first tried the experiment himself with a fine glass capillary tube. The flame was not visible at the end of this tube, being overpowered by the brilliant star of the glass ignited at the aperture.

Dr. Clarke, after being informed by Sir H. Davy that there would be no danger of explosion in burning the compressed gases, by suffering them to pass through a fine thermometer tube 1-80th of an inch diameter, and three inches in length; commenced a series of experiments, which were attended with most important and striking results. By the suggestion of Professor Cumming, there has been enclosed in the iron box a small cylinder of safety, about half filled with oil, and stuffed at top with fine wire gauze. The condensed gases must pass from the large chamber into this small one, up through the oil, and then across the gauze, before they can reach the stop-cock and blowpipe nozzle. By this means, the dangerous explosions, which had occurred so frequently as would have deterred a less intrepid experimenter than Dr. Clarke, are now obviated. It is still, however, a prudent precaution, to place a wooden screen between the box and the operator. The box is about five inches long, four broad, and three deep. The syringe is joined to the top of the box by a stop-cock. Near the upper end of the syringe, a screw nozzle is fixed in it at right angles, to which the stop-cock of a bladder containing the mixed gases may be attached. When we wish to inject the gases, it is proper to draw the piston to the top, before opening the lower stop-cock, lest the flame of the jet should be sucked backward, and cause explosion. It is likewise necessary to see that no little explosion has dislodged the oil from the safety cylinder. A bubbling noise is heard when the oil is present. A slight excess of hydrogen is found to be advantageous.

Platinum is not only fused the instant it is brought in contact with the flame of the ignited gases, but the melted metal runs down in drops. Dr. Clarke has finally fused the astonishing quantity of half an ounce at once, by this jet of flame. In small quantities, it burns like iron wire. Palladium melted like lead. Pure lime becomes a wax-yellow vitrification. A lambent purple flame always accompanies its fusion. The fusion of magnesia is also attended with combustion. Strontites fused with a flame of an intense amethystine colour, and after some minutes there appeared a small oblong mass of shining metal in its centre. Silex instantly melted into a deep orange-coloured glass, which was partly volatilized. Alumina melted with great rapidity into globules of a yellowish transparent glass. In these experiments, supports of charcoal, platinum, or plumbago, were used with the same effect. The alkalis were fused and volatilized the instant they came in contact with the flame, with an evident appearance of combustion.

The following refractory native compounds were fused. Rock crystal, white quartz, noble opal, flint, calcedony, Egyptian jasper, zircon, spinelle, sapphire, topaz, cymophane, pycnite, andalusite, wavellite, rubellite, hyperstene, cyanite, talc, serpentine, hyalite, lazulite, gadolinite, leucite, apatite, Peruvian emerald, Siberian beryl, potstone, hydrate of magnesia, subsulphate of alumina, pagodite *of China*, Iceland spar, common chalk, *Arragonite*, diamond.

Gold exposed on pipe-clay to the flame was surrounded with a *hulo* of a lively rose colour, and soon volatilized. Stout iron wire was rapidly burned. Plumbago was fused into a magnetic bead. Red oxide of titanium fused, with partial combustion. Red ferriferous copper blende, oxides of platinum, grey oxide of manganese, crystallized oxide of manganese, wolfram, sulphuret of molybdenum, siliceo-calcareous titanium, black oxide of cobalt, pechblende, siliciferous oxide of cerium, chromate of iron, and ore of iridium, were all, except the second last, reduced to the metallic state, with peculiar, and for the most part, splendid phenomena. Jade, mica, amianthus, asbestus, melt like wax before this potent flame.

But the two most surprising of Dr. Clarke's experiments were the fusion of the meteoric stone from L'Aigle, and its conversion into *iron;* and the reduction of *barium*, from the earth barytes and its salts. Some nitrate of barytes, put into a cavity, at the end of a stick of charcoal, was exposed to the ignited gas. It fused with vehement ebullition, and metallic globules were clearly discernible in the midst of the boiling fluid, suddenly forming, and as suddenly disappearing. On checking the flame, the cavity of the charcoal was studded over with innumerable globules of a metal of the most brilliant lustre and whiteness, resembling the purest platinum after fusion. Some globules were detached and dropped into naphtha, where they retained for some time their metallic aspect. Their specific gravity was 4.00.

Dr. Clarke fused together a bead of barium and one of platinum, each weighing one grain. The bronze-coloured alloy weighed two grains, proving a real combination. The alloy of barium and iron is black and brittle. Barium is infusible before the blowpipe *per se;* but with borax it dissolves like barytes, with a chrysolite-green colour, and disclosing metallic lustre to the file. The alloy of barium and copper is of a vermilion colour. When silex is mixed into a paste with lamp-oil, and exposed on a cavity of charcoal to the flame, it runs readily into beads of various colours. If these be heated in contact with iron, an alloy of silicum and iron is obtained, which discloses a metallic surface to the file. Magnesium and iron may be alloyed in the same way.

By using from two to three volumes of hydrogen to one of oxygen, and directing the flame on pure barytes, supported on pincers of slate, Dr. Clarke apparently revived barium in larger quantities, so as to exhibit its qualities for some time. It gradually, however, passes again into pure barytes. Muriate of rhodium, placed in a charcoal crucible, yielded the metal rhodium, brilliant like platinum. It is malleable on the anvil. Oxide of uranium, from Cornwall, was also reduced to the metallic state.

It is now generally believed, that Dr. Clarke had been mistaken, with regard to the reduction of barytes to the metallic state; and that the globules which he formed, owed their lustre and polish to the fusion which the earth had undergone.

We shall conclude this article by the following experiment of Dr. Clarke's: If you take two pieces of tin-foil and platinum-foil of equal dimensions, and roll them together, and place the roll upon charcoal, and direct the flame of a candle cautiously towards the edges of the roll, at about a red heat, the two metals will combine with a sort of explosive force, scattering their melted particles off the charcoal, and emitting light and heat in a very surprising manner. Then there will remain upon the charcoal a film of glass, which, by further urging the flame towards it, will melt into a highly transparent globule of a sapphire-blue colour. Also if the platinum and tin be placed beside each other, as soon as the platinum becomes heated, you will observe a beautiful play of blue light upon the surface of the tin, becoming highly iridescent before it melts.

BLUE (PRUSSIAN). A combination of oxide of iron with cyanogen. See ACID (PRUSSIC), and IRON.

BLUE (SAXON). The best Saxon blue colour may be given by the following composition:

Mix one ounce of the best powdered indigo with four ounces of sulphuric acid, in a glass bottle or matrass, and digest it for one hour with the heat of boiling water, shaking the mixture at different times: then add twelve ounces of water to it, and stir the whole well, and when grown cold filter it.

Mr. Poerner adds one ounce of good dry potash at the end of twenty-four hours, and lets this stand as much longer, before he dilutes it with water. The cloth should be prepared with alum and tartar.

BOG ORES. See ORES OF IRON.

BOLE. A massive mineral, having a perfectly conchoidal fracture, a glimmering internal lustre, and a shining streak. Its colours are yellow-red, and brownish-black, when it is called mountain soap. It is translucent or opaque. Soft, so as to be easily cut, and to yield to the nail. It adheres to the tongue, has a greasy feel, and falls to pieces in water. Sp. grav. 1.4 to 2. It may be polished. If it be immersed in water after it is dried, it falls asunder with a crackling noise. It occurs in wacke and basalt, in Silesia, Hessia, and Sienna in Italy, and also in the cliffs of the Giant's Causeway, Ireland. The black variety is found in the trap rocks of the Isle of Sky.

BOLOGNIAN STONE. Lemery reports, that an Italian shoemaker, named Vincenzo Casciarolo, first discovered the phosphoric property of the Bolognian stone. It is the ponderous spar, or native sulphate of barytes.

If it be first heated to ignition, then finely powdered, and made into a paste with mucilage; and this paste, divided into pieces a quarter of an inch thick, and dried in a moderate heat, be exposed to the heat of a wind furnace, by placing them loose in the midst of the charcoal; a pyrophorus will be obtained, which, after a few minutes' exposure to the sun's rays, will give light enough in the dark to render the figures on the dial-plate of a watch visible.

BOLETIC ACID. See ACID (BOLETIC).

BOLETUS. A genus of mushroom, of which several species have been subjected to chemical examination by MM. Braconnot and Bouillon La Grange.

1. *Boletus juglandis*, in 1200 parts, yielded 1118.3 water, 95.68 fungin, 18 animal matter insoluble in alcohol, 12 osmazome, 7.2 vegetable albumen, 6 fungate of potash, 1.2 adipocere, 1.12 oily matter, 0.5 sugar of mushrooms, and a trace of phosphate of potash.

2. *Boletus laricis*, used on the continent in

medicine under the name of *agaric*. It is in white, light, friable pieces, of which the outside is like dark-coloured leather. Its taste, at first sweetish, soon passes into bitterness and acrimony. Its infusion in water is yellowish, sweet tasted, and reddens vegetable blues. It contains muriate of potash, sulphate of lime, and sulphate of potash. Water boiled on agaric, becomes gelatinous on cooling; and if the water be dissipated by evaporation, ammonia is exhaled by the addition of lime. Resin of a yellow colour, with a bitter-sour taste, may be extracted from it by alcohol. It yields benzoic acid, by Scheele's process. The strong acids act with energy on agaric, and the nitric evolves oxalic acid. Fixed alkalis convert it into a red jelly, which emits an ammoniacal smell.

3. *Boletus igniarius* is found in most countries, and particularly in the Highlands of Scotland, on the trunks of old ash and other trees. The French and Germans prepare it abundantly for making *tinder*, by boiling in water, drying, beating it, and steeping it in a solution of nitre, and again drying it. In France it is called *amadou*, in this country *German tinder*. It has been recommended in surgery, for stopping hæmorrhage from wounds. It imparts to water a deep brown colour, and an astringent taste. The liquid consists of lime, muriate of potash, and a brown extractive matter. When the latter is evaporated to dryness, and burned, it leaves a good deal of potash. Phosphates of lime and magnesia, with some iron, are found in the insoluble matter. Alkalis convert it with some difficulty into a soapy liquid, exhaling ammonia. No benzoic acid, and little animal matter, are found in this boletus.

4. *Boletus pseudo-igniarius*, yielded to Braconnot, water, fungin, a sweetish mucilage, boletate of potash, a yellow fatty matter, vegetable albumen, a little phosphate of potash, acetate of potash, and fungic acid combined with a base.

5. *Boletus viscidus* was found by Braconnot to be composed, in a great measure, of an animal mucus, which becomes cohesive by heat.

BONE. The bones of men and quadrupeds owe their great firmness and solidity to a considerable portion of the phosphate of lime which they contain. When these are rasped small, and boiled in water, they afford gelatinous matter, and a portion of fat or oil, which occupied their interstices.

Calcined human bones, according to Berzelius, are composed, in 100 parts, of 81.9 phosphate of lime, 3 fluate of lime, 10 lime, 1.1 phosphate of magnesia, 2 soda, and 2 carbonic acid. 100 parts of bones by calcination are reduced to 63. Fourcroy and Vauquelin found the following to be the composition of 100 parts of ox bones: 51 solid gelatin, 37.7 phosphate of lime, 10 carbonate of lime, and 1.3 phosphate of magnesia; but Berzelius gives the following as their constituents: 33.3 cartilage, 55.35 phosphate of lime, 3 fluate of lime, 3.85 carbonate of lime, 2.05 phosphate of magnesia, and 2.45 soda, with a little common salt.

About 1-30th of phosphate of magnesia was obtained from the calcined bones of fowls, by Fourcroy and Vauquelin. When the enamel of teeth, rasped down, is dissolved in muriatic acid, it leaves no albumen, like the other bones. Fourcroy and Vauquelin state its components to be 27.1 gelatin and water, 72.9 phosphate of lime. Messrs. Hatchett and Pepys rate its composition at 78 phosphate of lime, 6 carbonate of lime, and 16 water and loss. Berzelius, on the other hand, found only 2 per cent. of combustible matter in teeth. The teeth of adults, by Mr. Pepys, consist of 64 phosphate of lime, 6 carbonate of lime, 20 cartilage, and 10 water or loss. The fossil bones from Gibraltar, are composed of phosphate of lime and carbonate, like burnt bones. Much difference of opinion exists with regard to the existence of fluoric acid in the teeth of animals, some of the most eminent chemists taking opposite sides of the question. It appears that bones buried for many centuries still retain their albumen, with very little diminution of its quantity.

Fourcroy and Vauquelin discovered phosphate of magnesia in all the bones they examined, except human bones. The bones of the horse and sheep afford about 1-36th of phosphate of magnesia; those of fish nearly the same quantity as those of the ox. They account for this by observing, that phosphate of magnesia is found in the urine of man, but not in that of animals, though both equally take in a portion of magnesia with their food.

The experiments of Mr. Hatchett show, that the membranous or cartilaginous substance, which retains the earthy salts within its interstices, and appears to determine the shape of the bone, is albumen. Mr. Hatchett observes, that the enamel of teeth is analogous to the porcellanous shells, while mother-of-pearl approaches in its nature to true bone.

A curious phenomenon with respect to bones, is the circumstance of their acquiring a red tinge, when madder is given to animals with their food. The bones of young pigeons will thus be tinged of a rose colour in twenty-four hours, and of a deep scarlet in three days; but the bones of adult animals will be a fortnight in acquiring a rose colour. The bones most remote from the heart are the longest in acquiring this tinge. Mr. Gibson informs us, that extract of logwood too, in considerable quantity, will tinge the bones of young pigeons purple. On desisting from the use of this food, however, the colouring matter is again taken up into the circulation, and carried off, the bones regaining their natural hue in a short time. It was said by Du Hamel, that the bones would become coloured and colourless in concentric layers, if an animal were fed alternately one week with madder, and one week without; and hence he inferred, that the bones were formed in the same manner as the woody parts of trees. But he was mistaken in the fact; and indeed had it been true, with the inference he naturally draws from it, the bones of animals must have been out of all proportion larger than they are at present.

Bones are of extensive use in the arts. In their natural state, or dyed of various colours, they are made into handles of knives and forks, and numerous articles of turnery. We have already noticed the manufacture of volatile alkali from bones, the coal of which forms bone-black; or, if they be afterwards calcined to whiteness in the open air, they constitute the bone ashes of which cupels are made, and which, finely levigated, are used for cleaning articles of paste, and some other trinkets, by the name of burnt hartshorn. The shavings of hartshorn, which is a species of bone, afford an elegant jelly; and the shavings of other bones, of which those of the calf are the best, are often employed in their stead.

On this principle, Mr. Proust has recommended an economical use of bones, particularly with a view to improve the subsistence of the soldier. He first chops them into small pieces, throws them into a kettle of boiling water, and lets them boil about a quarter of an hour. When this has stood till it is cold, a quantity of fat, excellent for culinary purposes when fresh, and at any time fit for making candles, may be taken off the liquor. This in some instances amounted to an eighth, and in others even to a fourth, of the weight of the bones. After this the bones may be ground, and boiled in eight or ten times their weight of water, of which that already used may form a part, till about half is wasted, when a very nutritious jelly will be obtained. The boiler should not be of copper, as this metal is easily dissolved by the jelly; and the cover should fit very tight, so that the heat may be greater than that of boiling water, but not equal to that of Papin's digester, which would give it an empyreuma. The bones of meat that have been boiled are nearly as productive as fresh bones; but Dr. Young found those of meat that had been roasted afforded no jelly, at least by simmering, or gentle boiling.

BORACIC ACID. See ACID (BORACIC). This acid has been found native on the edges of hot springs, near Sapo in the territory of Florence; also attached to specimens from the Lipari Islands, and from Monte Rotondo, to the west of Sienna. It is in small pearly scales, and also massive, fusing at the flame of a candle into a glassy globule. It consists, by Klaproth's analysis, of 86 boracic acid, 11 ferruginous sulphate of manganese, and 3 sulphate of lime.

BORACITE. Borate of magnesia. It is found in cubic crystals, whose fracture is uneven, or imperfectly conchoidal. Shining greasy lustre; translucent: so hard as to strike fire with steel; of a yellowish, greyish, or greenish-white. Sp. grav. 2.56. It becomes electric by heat; and the diagonally opposite solid angles are in opposite electrical states. It fuses into a yellow enamel, after emitting a greenish light.

Vauquelin's analysis gives, 83.4 boracic acid, and 16.6 magnesia. It occurs in gypsum in the Kalkberg in the duchy of Brunswick, and at Segeberg, near Kiel in Holstein.

BORATE. Salts composed with Boracic Acid.

BORAX. The origin of borax was for a long time unknown in Europe. Mr. Grill Abrahamson, however, sent some to Sweden in the year 1772, in a crystalline form, as dug out of the earth in Thibet, where it is called Pounnxa, Mypoun, and Houipoun; it is said to have been also found in Saxony, in some coal pits.

It does not appear that borax was known to the ancients, their chrysocolla being a very different substance, composed of the rust of copper, triturated with urine. The word borax is found for the first time in the works of Geber.

Borax is not only found in the East, but likewise in South America. Mr. Anthony Carera, a physician established at Potosi, informs us, that this salt is abundantly obtained at the mines of Requintipa, and those in the neighbourhood of Escapa, where it is used by the natives in the fusion of copper ores.

The purification of borax by the Venetians and the Hollanders, was for a long time kept secret. Chaptal finds, after trying all the processes in the large way, that the simplest method consists in boiling the borax strongly, and for a long time, with water. This solution being filtered, affords by evaporation crystals, which are somewhat foul, but may be purified by repeating the operation.

Purified borax is white, transparent, rather greasy in its fracture, affecting the form of six-sided prisms, terminating in three-sided or six-sided pyramids. Its taste is styptic; it converts syrup of violets to a green; and when exposed to heat, it swells up, boils, loses its water of crystallization, and becomes converted into a porous, white, opaque mass, commonly called Calcined Borax. A stronger heat brings it into a state of quiet fusion; but the glassy substance thus afforded, which is transparent, and of a greenish-yellow colour, is soluble in water, and effloresces in the air. It requires about eighteen times its weight of water to dissolve it at the temperature of sixty degrees of Fahrenheit; but water at the boiling heat dissolves three times this quantity. Its component parts, according to Kirwan, are, boracic acid 34, soda 17, water 47. For an account of the neutral borate of soda, and other compounds of this acid, see Acid (Boracic).

Borax is used as an excellent flux in docimastic operations. It enters into the composition of reducing fluxes, and is of the greatest use in analysis by the blowpipe. It may be applied with advantage in glass manufactories; for when the fusion turns out bad, a small quantity of borax re-establishes it. It is more especially used in soldering; it assists the fusion of the solder, causes it to flow, and keeps the surface of the metals in a soft or clean state, which facilitates the operation. It is scarcely of any use in medicine. Its acid, called *sedative salt*, is used by some physicians; and its name sufficiently indicates its supposed effects. Mixed with shell lac, in the proportion of one part to five, it renders the lac soluble by digestion in water, heated near boiling.

BORON. The combustible basis of boracic acid.

The easiest and most economical method of preparing boron, is to decompose an alkaline borofluate by potassium. For this purpose, borofluate of potash is formed by mixing fluate of potash with a solution of borate of potash. The borofluate falls in a gelatinous precipitate, which by desiccation assumes the form of a fine mealy white coloured powder. Its taste is weakly bitter, but not at all acid, nor does it redden litmus paper. It is anhydrous. 100 parts of water dissolve only 1.42 of this salt; but boiling water dissolves it in considerably larger quantity. It is slightly soluble also in boiling alcohol. When ignited it fuses, and gives off fluoboric acid gas; but for complete decomposition it requires a much longer continued, and more violent heat than the corresponding salt of silica (fluo-silicate of potash). The borofluate is soluble in boiling hot solutions of the alkalis and their carbonates, and as the liquid cools it crystallizes again unaltered. As boracic acid, even by protracted fusion, cannot be completely deprived of water, and as it absorbs an additional quantity during pulverization, a rather violent detonation is thereby caused during the reduction of boracic acid by potassium; so that a portion of the mixture is in general projected from the crucible. On the contrary, when the borofluate of potash has been sufficiently dried, the sound at the instant of reduction is scarcely audible, and for every atom of potassium expended we obtain the corresponding quantity of boron. The boron must be well washed with a solution of sal ammoniac, and finally with alcohol, because when pure water is employed for this purpose, a considerable quantity passes in the dissolved state through the filter.

Sulphuret of boron. Boron is capable of forming a sulphuret, but, contrary to what has been hitherto supposed, no combination takes place between the two substances, except in a temperature greatly exceeding the boiling point of sulphur. It takes fire and burns when strongly ignited in the vapour of sulphur. The sulphuret is a white opaque mass. When put into water it is rapidly converted into sulphuretted hydrogen gas and boracic acid; the liquid becomes at the same time more or less milky, in consequence of the precipitation of sulphur. Berzelius is led to think, that boron is capable of combining in several distinct proportions with sulphur.

Chloride of boron. Sir H. Davy ascertained, that boron even without the application of heat takes fire spontaneously in chlorine gas, and undergoes brilliant combustion. If it be however very pure, and previously ignited *in vacuo*, no combination takes place with chlorine till heat be applied. The product of the combustion is a *new gas*, which, in contact with the atmospheric air, smokes as strongly as fluoboric acid gas. It must be collected over mercury, which absorbs the excess of chlorine. This gas is colourless, and in consequence of the formation of muriatic acid at the expense of the atmospheric humidity, it has a strong suffocating odour. It is rapidly, but not instantaneously, absorbed by water, and when the proportion of the water is small, a quantity of boracic acid is deposited upon its surface. Alcohol also dissolves it, and acquires the same odour of ether as when it has absorbed muriatic acid gas. Chloride of boron, when mixed with ammoniacal gas, condenses and forms a salt, which may be sublimed unaltered, but which is less volatile than sal ammoniac. If the salt be moistened previously to sublimation, there remains a quantity of boracic acid. 1 volume of the gas condenses $1\frac{1}{2}$ volume of ammoniacal gas. Chloride of boron is composed of

Chlorine	- -	90.743
Boron	- -	9.257

Fluoric acid, unless aided by nitric acid, neither oxidates nor dissolves boron.

When boron is ignited with an alkaline carbonate, it detonates at the expense of the carbonic acid; and when it is ignited with the hydrate of a fixed alkali, hydrogen gas is disengaged with effervescence, and boracic acid is formed.

In the properties now brought under review, boron possesses so close a resemblance to silicium, that the two substances may be associated with one another, in the same manner as arsenic has been associated with phosphorus, and selenium with sulphur. The affinities of boron are, however, stronger, and, in the lower temperatures, more active than those of silicium. Thus it detonates with nitre in a low red heat, with such energy that the explosion may be compared almost to that of gunpowder. *Berzelius, Annals of Phil. N. S.* x. 129.

M. Dumas states, that a mixture of borax and charcoal being put into contact with dry chlorine at a red heat, yields abundance of the chloride of boron. He took advantage of it in the analysis of boracic acid; for when it decomposes water it gives muriatic and boracic acids. But its most important property is that of forming a solid hydrate, susceptible of being reduced by hydrogen and the heat of a spirit lamp; it becomes muriatic acid and *boron*, and in this way the latter substance may be obtained in large quantities. *Ann. de Chim.* xxxi. 433.

BOTANY-BAY RESIN exudes spontaneously from the trunk of the *acarois resinifera* of New Holland, and also from the wounded bark. It soon solidifies by the sun, into pieces of a yellow colour of various sizes. It pulverizes easily without caking; nor does it adhere to the teeth when chewed. It has a slightly sweet astringent taste. It melts at a moderate heat. When kindled, it emits a white fragrant smoke. It is insoluble in water, but imparts to it the flavour of storax. Out of nine parts, six are soluble in water, and astringent to the taste; and two parts are woody fibre.

BOTTLE GLASS. See Glass.

BOTRYOLITE is a mineral which occurs in mamillary concretions, formed of concentric layers; and also in botroidal masses, white and earthy. Its colour is pearl and yellowish-grey, with sometimes reddish-white concentric stripes. It has a rough and dull surface, and a pearly lustre internally. Fracture delicate, stellular, fibrous. Translucent on the edges. Brittle, but moderately hard. Sp. gr. 2.85. It is composed of 36 silica, 39.5 boracic acid, 13.5 lime, 1 oxide of iron, 6.5 water. It froths and fuses before the blowpipe into a white glass. It is found in a bed of gneiss near Arendahl, in Norway. It is regarded by some as a variety of datholite.

BOULDER STONES. Rolled blocks of granite; often found in valleys at a great distance from the granite mountains, even where lakes and mountains of another structure intervene.—See *the Introduction to Conybeare and Phillip's Geology of England and Wales*, pp. 29 *and* 30. See also *D'Aubuisson*, *Traité de Geognosie*, i. 231. and *Annales de Chim. et de Phys.* tom. vii. and x.

BOURNONITE. An antimonial sulphuret of lead.

BOVEY COAL. This is of a brown or brownish-black colour, and lamellar texture; the laminæ are frequently flexible when first dug, though generally they harden when exposed to the air. It consists of wood penetrated with petroleum or bitumen, and frequently contains pyrites, alum, and vitriol: its ashes afford a small quantity of fixed alkali, according to the German chemists; but according to Mr. Mills, they contain none. By distillation it yields an ill-smelling liquor, mixed with volatile alkali and oil, part of which is soluble in alcohol, and part insoluble, being of a mineral nature.

It is found in England, France, Italy, Switzerland, Germany, Iceland, &c.

BOYLE'S FUMING LIQUOR. Hydroguretted sulphuret of ammonia.

BRAIN OF ANIMALS. The brain has long been known to anatomists; but it is only of late years that chemists have paid it any attention. It is a soft white substance, of a pulpy saponaceous feel, and little or no smell. Exposed to a gentle heat, it loses moisture, shrinks to about a fourth of its original bulk, and becomes a tenacious mass of a greenish-brown colour. When completely dried, it becomes solid, and friable like old cheese. Exposed to a strong heat, it gives out ammonia, swells up, melts into a black pitchy mass, takes fire, burns with much flame and a thick pungent smoke, and leaves a coal difficult of incineration.

In its natural state, or moderately dried, it readily forms an emulsion by trituration with water, and is not separated by filtration. This solution lathers like soap-suds, but does not turn vegetable blue colours green. Heat throws down the dissolved brain in a flocculent form, and leaves an alkaline phosphate in solution. Acids separate a white coagulum from it; and form salts with bases of lime, soda, and ammonia. Alcohol too coagulates it.

Caustic fixed alkalis act very powerfully on brain even cold, evolving much ammonia and caloric. With heat they unite with it into a saponaceous substance.

The action of alcohol on brain is most remarkable. When Fourcroy treated it four times in succession with twice its weight of well rectified alcohol, boiling it a quarter of an hour each time, in a long-necked matrass with a grooved stopple, the three first portions of alcohol, decanted boiling, deposited by cooling brilliant laminæ of a yellowish-white colour, diminishing in quantity each time. The fourth deposited very little. The cerebral matter had lost 5-8ths of its weight; and by the spontaneous deposition, and the subsequent evaporation of the alcohol, half of this was recovered in needly crystals, large scales, or granulated matter. The other half was lost by volatilization. This crystallized substance, of a fatty appearance, was agglutinated into a paste under the finger; but did not melt at the heat of boiling water, being merely softened. At a higher temperature it suddenly acquired a blackish-yellow colour, and exhaled during fusion an empyreumatic and ammoniacal smell. This shows that it is not analogous to spermaceti, or to adipocere; but it seems more to resemble the fat lamellated crystals contained in some biliary calculi, which, however, do not soften at a heat of 234° F. or become ammoniacal and empyreumatic at this temperature, as the crystalline cerebral oil does.

A portion of this concrete oil, separated from the alcohol by evaporation in the sun, formed a granulated pellicle on its surface, of a consistence resembling that of soft soap. It was of a yellower colour than the former, and had a marked smell of animal extract, and a perceptible saline taste. It was diffusible in water, gave it a milky appearance, reddened litmus paper, and did not become really oily or fusible after the manner of an oil, till it had given out ammonia, and deposited carbon, by the action of fire or caustic alkalis.

A similar action of alcohol on the brain, nerves, and spinal marrow, is observed after long maceration in it cold, when they are kept as anatomical preparations.

Vauquelin analyzed the brain, and found the following constituents in 100 parts: 80 water, 4.53 white fatty matter, 0.7 reddish fatty matter, 7 albumen, 1.12 osmazome, 1.5 phosphorus, 5.15 acids, salts, and sulphur. The medulla oblongata and nerves have the same chemical composition.

The spontaneous change that brain undergoes in certain situations, has already been noticed under the article ADIPOCERE.

BRANDY. This well known fluid is the spirit distilled from wine. The greatest quantities are made in Languedoc, where this manufacture, upon the whole so pernicious to society, first commenced. It is obtained by distillation in the usual method by a still, which contains five or six quintals of wine, and has a capital and worm tube applied. Its peculiar flavour depends, no doubt, on the nature of the volatile principles, or essential oil, which come over along with it, and likewise, in some measure, upon the management of the fire, the wood of the cask in which it is kept, &c. It is said, that our rectifiers imitate the flavour of brandy, by adding a small proportion of nitrous ether to the spirit of malt or molasses. See ALCOHOL.

BRASS. A yellow-coloured compound metal, consisting of copper combined with about one-half of its weight of zinc. The best brass is made by cementation of calamine, or the ore of zinc, with granulated copper. See COPPER.

BRASSICA RUBRA. The red cabbage affords a very excellent test both for acids and alkalis; in which it is superior to litmus, being naturally blue, turning green with alkalis, and red with acids. The minced leaves may be dried before the fire till they become quite crisp, when they ought to be put into a bottle, and corked up. Hot water, poured on a little of the dried leaves, affords an extemporaneous test liquor for acids and alkalis. The purple petals of violets may be preserved in the same way; as well as those of the pink-coloured *lychnis*, and scarlet rose.

BRAZIL WOOD. The tree that affords this wood, the cæsalpina crista, is of the growth of the Brazils in South America, and also of the Isle of France, Japan, and elsewhere. It is chiefly used in the process of dyeing. The wood is considerably hard, is capable of a good polish, and is so heavy that it sinks in water. Its colour is pale when newly cut, but it becomes deeper by exposure to the air. The various specimens differ in the intensity of their colour; but the heaviest is reckoned the most valuable. It has a sweetish taste when chewed, and is distinguished from red sanders, or sandal, by its property of giving out its colour with water, which this last does not.

If the brazil wood be boiled in water for a sufficient time, it communicates a fine red colour to that fluid. The residue is very dark coloured, and gives out a considerable portion of colouring matter to a solution of alkali. Alcohol extracts the colour from brazil wood, as does likewise the volatile alkali; and both these are deeper than the aqueous solution. The spirituous tincture, according to Dufay, stains warm marble of a purplish-red, which on increasing the heat becomes violet; and if the stained marble be covered with wax, and considerably heated, it changes through all the shades of brown, and at last becomes fixed of a chocolate colour.

The colours imparted to cloth by brazil wood are of little permanence. A very minute portion of alkali, or even soap, darkens it into purple. Hence paper stained with it may be used as a test of saturation with the salts. Alum added to the decoction of this wood occasions a fine crimson-red precipitate, or lake, which is increased in quantity by the addition of alkali to the liquor. The crimson-red colour is also precipitated by muriate of tin: but it is darkened by the salts of iron. Acids change it to yellow, from which, however, solution of tin restores it to its natural hue. The extract of brazil wood reddens litmus paper, by depriving it of the alkali which darkens it.

BREAD. When flour is kneaded together with water, it forms a tough paste, containing these principles very little altered, and not easily digested by the stomach. The action of heat produces a considerable change in the gluten, and probably in the starch, rendering the compound more easy to masticate, as well as to digest. Hence the first approaches towards the making of bread consisted in parching the corn, either for immediate use as food, or previous to its trituration into meal; or else in baking the flour into unleavened bread or boiling it into masses more or less consistent; of all which we have sufficient indications in the histories of the earlier nations, as well as in the various practices of the moderns. It appears likewise from the Scriptures, that the practice of making leavened bread is of very considerable antiquity; but the addition of yeast, or the vinous ferment, now so generally used, seems to be of modern date.

Unleavened bread, in the form of small cakes, or biscuit, is made for the use of shipping in large quantities; but most of the bread used on shore is made to undergo, previous to baking, a kind of fermentation, which appears to be of the same nature as the fermentation of saccharine substances: but is checked and modified by so many circumstances, as to render it not a little difficult to speak with certainty and precision respecting it.

When dough or paste is left to undergo a spontaneous decomposition in an open vessel, the various parts of the mass are differently affected, according to the humidity, the thickness or thinness of the part, the vicinity or remoteness of fire, and other circumstances less easily investigated. The saccharine part is disposed to become converted into alcohol, the mucilage has a tendency to become sour and mouldy, while the gluten in all probability verges toward the putrid state. An entire change in the chemical attractions of the several component parts must then take place in a progressive manner, not altogether the same in the internal and more humid parts as in the external parts, which not only become dry by simple evaporation, but are acted upon by the surrounding air. The outside may therefore become mouldy or putrid, while the inner part may be only advanced to an acid state. Occasional admixture of the mass would of course not only produce some change in the rapidity of this alteration, but likewise render it more uniform throughout the whole. The effect of this commencing fermentation is found to be, that the mass is rendered more digestible and light; by which last expression it is understood that it is rendered much more porous by the disengagement of elastic fluid, that separates its parts from each other, and greatly increases its bulk. The operation of baking puts a stop to this process, by evaporating great part of the moisture which is requisite to favour the chemical attraction, and probably also by still farther changing the nature of the component parts. It is then bread.

Bread made according to the preceding method will not possess the uniformity which is requisite, because some parts may be mouldy, while others are not yet sufficiently changed from the state of dough. The same means are used in this case as have been found effectual in promoting the uniform fermentation of large masses. This consists in the use of a leaven or ferment, which is a small portion of some matter of the same kind, but in a more advanced stage of the fermentation. After the leaven has been well incorporated by kneading into fresh dough, it not only brings on the fermentation with greater speed, but causes it to take place in the whole of the mass at the same time; and as soon as the dough has by this means acquired a due increase of bulk from the carbonic acid, which endeavours to escape, it is judged to be sufficiently fermented, and ready for the oven.

The fermentation by means of leaven or sour dough is thought to be of the acetous kind, because it is generally so managed, that the bread has a sour flavour and taste. But it has not been ascertained that this acidity proceeds from true vinegar. Bread raised by leaven is usually made of a mixture of wheat and rye, not very accurately cleared of the bran. It is distinguished by the name of rye bread; and the mixture of these two kinds of grain is called bread-corn, or meslin, in many parts of the kingdom, where it is raised on one and the same piece of ground, and passes through all the processes of reaping, threshing, grinding, &c. in this mixed state.

Yeast or barm is used as the ferment for the finer kinds of bread. This is the mucilaginous froth which rises to the surface of beer in its first stage of fermentation. When it is mixed with dough, it produces a much more speedy and effectual fermentation than that obtained by leaven, and the bread is accordingly much lighter, and scarcely ever sour. The fermentation by yeast seems to be almost certainly of the vinous or spirituous kind.

Bread is much more uniformly miscible with water than dough; and on this circumstance its good qualities most probably do in a great measure depend.

A very great number of processes are used by cooks, confectioners, and others, to make cakes, puddings, and other kinds of bread, in which different qualities are required. Some cakes are rendered brittle, or as it is called *short*, by an admixture of sugar or of starch. Another kind of brittleness is given by the addition of butter or fat. White of egg, gum-water, isinglass, and other adhesive substances, are used, when it is intended that the effect of fermentation shall expand the dough into an exceedingly porous mass. Dr. Percival has recommended the addition of salep, or the nutritious powder of the orchis root. He says, that an ounce of salep, dissolved in a quart of water, and mixed with two pounds of flour, two ounces of yeast, and eighty grains of salt, produced a remarkably good loaf, weighing three pounds two ounces; while a loaf made of an equal quantity of the other ingredients, without the salep, weighed but two pounds twelve ounces. If the salep be in too large quantity, however, its peculiar taste will be distinguishable in the bread. The farina of potatoes likewise, mixed with wheaten flour, makes very good bread. The reflecting chemist will receive considerable information on this subject from an attentive inspection of the receipts to be met with in treatises of cooking and confectionery.

Mr. Accum, in his late Treatise on Culinary Poisons, states, that the inferior kind of flour which the London bakers generally use for making loaves, requires the addition of alum to give them the white appearance of bread made from fine flour. "The bakers' flour is very often made of the worst kinds of damaged foreign wheat, and other cereal grains mixed with them in grinding the wheat into flour. In this capital, no fewer than six distinct kinds of wheaten flour are brought into the market. They are called fine flour, seconds, middlings, fine middlings, coarse middlings, and twenty-penny flour. Common garden beans and pease are also frequently ground up among the London bread flour.

"The smallest quantity of alum that can be employed with effect to produce a white, light, and porous bread from an inferior kind of flour, I have my own baker's authority to state, is from three to four ounces to a sack of flour weighing 240 pounds."

"The following account of making a sack or five bushels of flour into bread, is taken from Dr. P. Markham's Considerations on the Ingredients used in the Adulteration of Flour and Bread, p. 21.

Five bushels flour,
Eight ounces of alum,
Four lbs. salt,
Half a gallon of yeast mixed, with about
Three gallons of water.

"Another substance employed by fraudulent bakers is subcarbonate of ammonia. With this salt they realize the important consideration of producing light and porous bread from spoiled, or what is technically called *sour flour*. This salt, which becomes wholly converted into a gaseous substance during the operation of baking, causes the dough to swell up into air bubbles, which carry before them the stiff dough, and thus it renders the dough porous; the salt itself is at the same time totally volatilized during the operation of baking."—"Potatoes are likewise largely, and perhaps constantly used by fraudulent bakers, as a cheap ingredient, to enhance their profit."—"There are instances of convictions on record, of bakers having used gypsum, chalk, and pipe-clay, in the manufacture of bread."

Mr. E. Davy, Prof. of Chemistry at the Cork Institution, has made experiments, showing that from twenty to forty grains of common carbonate of magnesia, well mixed with a pound of the worst *new seconds* flour, materially improved the quality of the bread baked with it.

The habitual and daily introduction of a portion of alum into the human stomach, however small, must be prejudicial to the exercise of its functions, and particularly in persons of a bilious and costive habit. And besides, as the best sweet flour never stands in need of alum, the presence of this salt indicates an inferior and highly acescent food; which cannot fail to aggravate dyspepsia, and which may generate a calculous diathesis in the urinary organs. Every precaution of science and law ought therefore to be employed to detect and stop such deleterious adulterations. Bread may be analyzed for alum by crumbling it down when somewhat stale in distilled water, squeezing the pasty mass through a piece of cloth, and then passing the liquid through a paper filter. A limpid infusion will thus be obtained. It is difficult to procure it clear if we use new bread or hot water. A dilute solution of muriate of barytes dropped into the filtered infusion, will indicate, by a white cloud, more or less heavy, the presence and quantity of alum. I find that genuine bread gives no precipitate by this treatment. The earthy adulterations are easily discovered by incinerating the bread at a red heat in a shallow earth vessel, and treating the residuary ashes with a little nitrate of ammonia. The earths themselves will then remain, characterized by their whiteness and insolubility.

Under *Process of Baking*, in the Supplement to the Encyclopedia Britannica, we have the following statement: "An ounce of alum is then dissolved over the fire in a tin-pot, and the solution poured into a large tub, called by the bakers the *seasoning-tub*. Four pounds and a half of salt are likewise put into the tub and a pailful of hot water." Note on this passage.—"In London, where the goodness of bread is estimated entirely by its whiteness, it is usual with those bakers who employ flour of an inferior quality, to add *as much* alum as common salt to the dough. Or, in other words the quantity of salt added is diminished one-half, and the deficiency supplied by an equal weight of alum. This improves the look of the bread very much, rendering it much whiter and firmer."

In a passage which we shall presently quote, our author represents the bakers of London joined in a conspiracy to supply the citizens with bad bread. We may hence infer, that the full allowance he assigns of 2¼ pounds of alum for every 2¼ pounds of salt, will be adopted in converting a sack of flour into loaves. But as a sack of flour weighs 280 pounds, and furnishes on an average 80 quartern loaves, we have 2¼ pounds divided by 80, or $\frac{15750 \text{ grains}}{80} = 197$ grains, for the quantity present by this writer in a London quartern loaf. Yet in the very same page (39th of volume 2d) we have the following passage: "Alum is not added by all bakers. The writer of this article has been assured by several bakers of respectability, both in Edinburgh and Glasgow, on whose testimony he relies, and who made excellent bread, that they never employed any alum. The reason for adding it given by the London bakers is, that it renders the bread whiter, and enables them to separate readily the loaves from each other. This addition has been alleged by medical men, and is considered by the community at large, as injurious to the health, by occasioning constipation. But if we consider the small quantity of this salt added by the baker, not quite 5½ grains to a quartern loaf, we will not readily admit these allegations. Suppose an individual to eat the seventh part of a quartern *loaf* a-day, he would only swallow eight-tenths of a grain of alum, or in reality not quite so much as half a grain, for one-half of this salt consists of water. It seems absurd to suppose that half a grain of alum, swallowed at different times during the course of a day, should occasion constipation." Is it not more absurd to state 2¼ pounds, or 36 ounces, as the alum adulteration of a sack of flour by the London bakers, and within a few periods to reduce the adulteration to *one* ounce?

That this voluntary abstraction of $\frac{35}{36}$ of the alum, and substitution of superior and more expensive flour, is not expected by him from the London bakers, is sufficiently evident from the following story. It would appear that one of his friends had invented a new yeast for fermenting dough, by mixing a quart of beer barm with a paste made of ten pounds of flour and two gallons of boiling water, and keeping this mixture warm for six or eight hours.

"Yeast made in this way," says he, "answers the purposes of the baker much better than brewers' yeast, because it is clearer, and free from the hop mixture, which sometimes injures the yeast of the brewer. Some years ago the bakers of London, sensible of the superiority of this artificial yeast, invited a company of manufacturers from Glasgow to establish a manufactory of it in London, and promised to use no other. About 5000*l.* accordingly were laid out on buildings and materials, and the manufactory was begun on a considerable scale. The ale brewers, finding their yeast, for which they had drawn a good price, lie heavy on their hands, invited *all* the journeymen bakers to their cellars, gave them their full of ale, and promised to regale them in that manner every day, provided they would force their masters to take all their yeast from the ale brewers. The journeymen accordingly declared in a *body*, that they would work no more for their masters unless they gave up taking any more yeast from the new manufactory. The masters were obliged to comply; the new manufactory was stopped; and the *inhabitants of London were obliged to continue to eat worse bread, because it was the interest of the ale brewers to sell the yeast.* Such is the influence of journeymen bakers in the metropolis of England!"

This doleful diatribe seems rather extravagant; for surely beer-yeast can derive nothing noxious, to a porter-drinking people, from a slight impregnation of hops; while it must form probably a more energetic ferment than the fermented paste of the new company, which at any rate could be prepared in six or eight hours by any baker who found it to answer his purpose of making a pleasant eating bread. But it is a very serious thing for a lady or gentleman of sedentary habits, or infirm constitution, to have their digestive process daily vitiated by damaged flour, whitened with 197 grains of alum per quartern loaf. Acidity of stomach, indigestion, flatulence, headachs, palpitation, costiveness, and urinary calculus, may be the probable consequences of the habitual introduction of so much acidulous and acescent matter.

I have made many experiments on bread, and have found the proportion of alum very variable. Its quantity seems to be proportional to the badness of the flour; and hence when the best flour is used, no alum need be introduced. That alum is not necessary for giving bread its utmost beauty, sponginess, and agreeableness of taste, is undoubted; since the bread baked at a very extensive establishment in Glasgow, in which about 20 tons of flour were regularly converted into loaves in the course of a week, unites every quality of appearance, with an absolute freedom from that acido-astringent drug. Six pounds of salt are used for every sack of flour; which from its good quality generally affords 83 or 84 quartern loaves of the legal weight, of four pounds five ounces and a half each. The loaves lose nine ounces in the oven. For an account of the constituents of wheat flour, see WHEAT.

BRECCIA. An Italian term, frequently used by our mineralogical writers to denote such compound stones as are composed of agglutinated fragments of considerable size. When the agglutinated parts are rounded, the stone is called pudding-stone. Breccias are denominated according to the nature of their component parts. Thus we have calcareous breccias, or marbles; and siliceous breccias, which are still more minutely classed, according to their varieties.

BREWING. See BEER, ALCOHOL, and FERMENTATION.

BRICK. Among the numerous branches of the general art of fashioning argillaceous earths into useful forms, and afterward hardening them by fire, the art of making bricks and tiles is by no means one of the least useful.

Common clay is scarcely ever found in a state approaching to purity on the surface of the earth. It usually contains a large proportion of siliceous earth. Bergmann examined several clays in the neighbourhood of Upsal, and made bricks which he baked with various degrees of heat, suffered them to cool, immersed them in water for a considerable time, and then exposed them to the open air for three years. They were formed of clay and sand. The hardest were those into the composition of which a fourth part of sand had entered. Those which had been exposed for the shortest time to the fire were almost totally destroyed, and crumbled down by the action of the air. Such as had been more thoroughly burned, suffered less damage; and in those which had been formed of clay alone, and were half vitrified by the heat, no change whatever was produced.

On the whole he observes, that the proportion of sand to be used to any clay, in making bricks, must be greater the more such clay is found to contract in burning; but that the best clays are those which need no sand. Bricks should be well burned; but no vitrification is necessary, when they can be rendered hard enough by the mere action of the heat. When a vitreous crust might be deemed necessary, he recommends the projection of a due quantity of salt into the furnace, which would produce the effect in the same manner as is seen in the fabrication of the English pottery called stoneware.

A kind of bricks called *fire-bricks* are made from slate-clay, which are very hard, heavy, and contain a large proportion of sand. These are chiefly used in the construction of furnaces for steam-engines, or other large works, and in lining the ovens of glass-houses, as they will stand any degree of heat. Indeed they should always be employed where fires of any intensity are required.

BRICKS (FLOATING). Bricks, that swim on water, were manufactured by the ancients; and Fabbroni discovered some years since a substance, at Castel del Piano, near Santa Fiora, between Tuscany and the States of the Church, from which similar bricks might be made. It constitutes a brown earthy bed, mixed with the remains of plants. Haüy calls it *talc pulverulent silicifère*, and Brochant considers it as a variety of *meerschaum*. The Germans name it *bergmehl* (mountain meal), and the Italians *latte di luna*, (moon milk). By Klaproth's analysis, it consists of 79 silica, 5 alumina, 3 oxide of iron, 12 water, and 1 loss, in 100 parts. It agrees nearly in composition with *Kieselguhr*.

BRILLIANT. Diamond, cut in such a way as to reflect light most vividly, is called a brilliant.

BRIMSTONE. See SULPHUR.

BRIONIA ALBA. A root used in medicine. By the analysis of Vauquelin, it is found to consist in a great measure of starch, with a bitter principle, soluble in water and alcohol, some gum, a vegeto-animal matter, precipitable by infusion of galls, some woody fibre, a little sugar, and supermalate and phosphate of lime. It has cathartic powers; but is now seldom prescribed by physicians.

BRITISH GUM. When starch is exposed to a temperature between 600° and 700° it swells, and exhales a peculiar smell; it becomes of a brown colour, and in that state is employed by calico printers. It is soluble in cold water, and does not form a blue compound with iodine. Vauquelin found it to differ from gum in affording oxalic instead of mucous acid, when treated with nitric acid. *Brande's Manual*, iii. 34.

BROCATELLO. A calcareous stone or marble, composed of fragments of four colours, white, grey, yellow, and red.

BROCHANTITE. A new mineral from the Bank mines of Ekaterinburg. Crystals in thin rectangular tables, of an emerald green colour, transparent; hardness as green carbonate of copper on which they lie. *Annals of Phil.* viii. 241.

BROME or BROMINE. A new elementary body of the electro-negative class, so called from the Greek name *βρωμος*, *fœtor*, because it possesses a very offensive smell.

After passing for some time a current of chlorine through the mother water of salt works, a quantity of ether must be poured on the surface of the liquid, so as entirely to fill up the flask into which it has been put. These two liquids are to be thoroughly intermixed by strong agitation, and then left at rest for a few instants, to allow them to separate from each other. The ether is now seen floating in a stratum of a fine hyacinthine red; while the mother water of the salt springs, deprived of colour, presents no more the lively and irritating odour of brome, but the soothing smell of the ether held in solution.

The ethereous solution of brome loses eventually its hue and disagreeable odour, on agitation with some alkaline substance, for example, with caustic potash. This absorbs the brome, and by agitating successively the mother water of salt works, rendered yellow by ether, and the coloured ether with potash, it is possible to combine with a small quantity of this alkali, the whole *brome*, afforded from a very large body of water.

The potash losing by degrees its alkaline qualities, is changed into a saline matter, soluble in water, and which crystallises in cubes by the evaporation of the liquid. From these cubic crystals brome is extracted.

The pulverized crystals, mixed with pure peroxide of manganese, being put into a retort, sulphuric acid, diluted with half its weight of water, is poured in. Ruddy vapours immediately rise, which condense into drops of brome. These may be collected by plunging the neck of the retort to the bottom of a small receiver containing cold water. The brome which comes over in vapour is dissolved in this liquid; but that which is condensed on the neck of the retort, under the form of little drops, falls to the bottom of the vessel from its great specific gravity.

Whatever may be the affinity of water for this body, the layer of liquid which surrounds it, is soon saturated, and then enclosing the brome on all sides, screens it from the solvent action of the upper *strata*. Finally, to procure it in a state of great purity, it is merely necessary to separate it, to free it from the water that it may retain, and to distil it from chloride of calcium.

Brome appears under the form of a blackish-red liquid, when viewed in mass and by reflected light, but of a hyacinthine red when a thin film of it is interposed between the light and the eye.

Its very unpleasant smell reminds one of that of the oxides of chlorine, though it is far more intense.

Its taste is peculiarly strong.

It attacks organic substances, as wood, cork, &c., and particularly the skin, which it tinges yellow and corrodes. This hue disappears after some time; but if the contact of the brome has continued somewhat long, the colour wears off only with the epidermis.

It acts with energy on the animal functions. A drop let fall into the beak of a bird was sufficient to kill it.

The specific gravity, taken on a minute quantity, was found to be 2.966.

Brome does not congeal at a temperature of 0° F.

It is volatile. When a drop of it is put into a vessel, this is immediately filled with the peculiar deep ruddy vapours, very similar to the fumes of nitrous acid. It boils at 116.6° F. But it suffers no change of nature on being transmitted through an ignited tube.

Brome is a non-conductor of voltaic electricity; for when a column of it, 3 or 4 lines long, is interposed in the circuit for decomposing water, the electrical action ceases.

Nor does electricity appear capable of decomposing brome; for it neither suffers diminution of volume, nor disengages any gas, when exposed to the action of that power.

The vapours of brome cannot support combustion. A lighted taper plunged into them, is soon extinguished; but before going out, it burns for some instants with a flame which is green at the base, and reddish towards the top, just as happens with chlorine gas.

Brome is soluble in water, alcohol, and particularly in ether. Sulphuric acid floats above brome, but dissolves a very minute portion of it. Oil of olives acts in a slow manner.

It does not redden tincture of litmus, but it speedily deprives it of colour, nearly as chlorine would do. The sulphuric solution of indigo is equally decoloured.

Brome unites with hydrogen to form hydrobromic acid. See ACID (HYDROBROMIC).

The action of brome on the metals, presents the most striking points of resemblance between it and chlorine. Antimony and tin burn when brought in contact with brome. Potassium, on uniting with it, disengages so much heat and light, that a detonation ensues sufficiently violent to break the vessel and project the materials.

The bromides thus directly formed, for instance that of potassium, seem to be identical in their appearance and properties, with those obtained by treating the metallic oxides with hydrobromic acid, either in the dry way, or by evaporating their liquid combinations. The hydro-bromates are easily recognized by the faculty which they possess of becoming yellow, and evolving brome, when any body strongly attractive of hydrogen acts on them, such as chlorine, or the chloric and nitric acids; whence the use of the first substance in the extraction of brome. All the bromides, indeed, are decomposed by chlorine with the disengagements of brome.

Bromide of potassium crystallizes in cubes, or sometimes in long rectangular parallelopipeds. It has a sharp taste. Exposed to the action of caloric it decrepitates, and undergoes igneous fusion, without undergoing any other change.

Chlorine decomposes it at an elevated temperature. Brome is disengaged, and chloride of potassium remains. Iodine has no action on it, even at an elevated temperature. On the other hand, brome made to pass over fused iodide of potassium, disengages violet vapours in abundance.

Boric acid does not decompose at a red heat, unless steam be transmitted over the ignited mixture. In this case, hydro-bromic acid is evolved.

Solution of this salt in water does dissolve no more brome than simple water.

Sulphuric acid decomposes it, with the disengagement of hydro-bromic acid and brome.

Bromide of potassium, decomposed by sulphuric acid, leaves sulphate of potash; whence the composition of the bromide seems to be, in 100 parts,

Brome	65.56
Potassium	34.44;

whence the prime equivalent of brome comes out 9.5 to oxygen 1. This is nearly the half sum of the atomic weights of chlorine and iodine.

Hydrobromate of ammonia, is formed by the union of equal volumes of hydrobromic acid and ammonia. It may also be formed in the liquid way from hydrobromic acid, or by putting brome into water of ammonia. The results of this action are the emission of heat without light, the disengagement of azote, and the formation of hydrobromate of ammonia. Nothing corresponding to chloride of azote seems to be produced.

Hydrobromate of ammonia is solid, white, becoming yellow in moist air, and thus acquires the faculty of reddening the blue of litmus paper. It crystallizes in long prisms, on which other smaller ones are implanted at right angles. It is volatilized by heat.

Hydrobromate of barytes. This salt is formed by agitating the ethereous solution of brome with hydrate of barytes, or by the direct union of barytes and hydrobromic acid.

Hydrobromate of barytes fuses on exposure to heat.

It is very soluble in water, as well as in alcohol.

Its crystals grouped under an opaque mammelated form, have no resemblance to the transparent scales of muriate of barytes.

Hydrobromate of magnesia is an uncrystallizable, deliquescent salt, decomposed like the muriate by exposure to a high heat.

Bromide of lead. When into a solution of a salt of lead some drops of a hydrobromate, dissolved in water, are poured, a white precipitate ensues of a crystalline aspect, like chloride of lead. This precipitate on being strongly heated fuses into a red liquid, which exhales thin white vapours. It afterwards concretes on cooling into a fine yellow mass, like mineral yellow. The pulverulent bromide of lead is decomposable by the nitric and sulphuric acids, with disengagement of brome in the first case, and of brome with hydrobromic acid in the second. After it has acquired a stony hardness by fusion, it is no longer acted on by nitric acid, but yields only to boiling sulphuric acid.

Deutobromide of tin. Tin dissolves in liquid hydrobromic acid with disengagement of hydrogen.

The resulting hydrobromate, evaporated to dryness, is transformed into a protobromide, very different from the combination obtained by the direct action of brome on tin, which is obviously a bi-bromide.

Tin burns in contact with brome, and is converted into a solid compound, white, of a crystalline appearance, very fusible, and easily volatilized. This bromide diffuses in moist air slight traces of white vapours. It dissolves in water without producing heat, and is converted into the acid deuto-bromate.

Placed in hot sulphuric acid it melts, and remains at the bottom of the liquid, in the form of drops of oil, without suffering any visible change. Nitric acid, on the other hand, produces in a few seconds a brisk evolution of brome.

The deutobromide of tin, corresponding to the fuming liquor of Libavius, possesses few of the properties of this compound.

Bromides of mercury. Mercury combines in several proportions with brome. A solution of an alkaline hydrobromate, acting on the protonitrate of mercury, determines the formation of a white precipitate, similar to calomel, and which appears to be a proto-bromide of this metal. Brome attacks mercury powerfully. The combination takes place with a disengagement of heat, without light. A white matter results, sublimable by heat, soluble in water, alcohol, and especially in ether, precipitable in a red or yellow form by alkalis, and presenting thus many analogies with corrosive sublimate. It is characterized, however, by the faculty of affording ruddy vapours of brome, when treated with nitric, and still more so with sulphuric acid, on account of the higher heat to which the latter may be subjected.

Bromide of silver. The nitrate of silver produces with the soluble hydrobromates, a curdy precipitate of bromide of silver.

This compound, of a pale canary-yellow hue when dried in the shade, blackens when moist in the light, but less easily than chloride of silver. Like it, it is insoluble in water, soluble in water of ammonia, and insoluble in nitric acid, which produces no effect on it, even at its boiling heat; but boiling sulphuric acid disengages from it some vapours of brome.

Bromide of silver fuses by heat into a reddish liquid, which concretes by cooling into a substance of a yellow colour, and a horny appearance. Hydrogen in the gaseous state can also effect its decomposition. Metallic silver and hydrobromic acid result. The bromide of silver was analyzed on this principle. A quantity exactly weighed was introduced into a mixture of pure zinc granulated, and dilute sulphuric acid. The silver was revived, and its weight was taken after the whole zinc had been completely dissolved away. The mean of two experiments, which differed little from each other, gave for the composition of this body, in 100 parts,

Silver	58.9
Brome	41.1

This makes the prime equivalent very nearly 9.6 to silver 13.75, which approaches very nearly to 10, the half sum of chlorine and iodine.

Bromide of gold. Brome, and its aqueous solution, dissolve *laminæ* of gold. A yellow bromide is thus procured, which gives a violet stain to animal substances, and is decomposed by heat into brome and metallic gold.

Platinum dissolves in bromo-nitric acid, though it is not acted on by brome at ordinary temperatures, and thereby forms a combination of a yellow colour, decomposable by heat, and which precipitates with the salts of potash and ammonia in a yellow powder, slightly soluble.

Brome, when transmitted in vapour over potash, soda, barytes, and lime, at a red heat, occasions a lively incandescence. Oxygen gas is evolved, and there is found in the interior of the glass tube bromides of potassium, sodium, &c. Oxide of zinc in the same circumstances does not act on brome. Ignited sulphate of potash resists the action of brome; but the alkaline carbonates are completely decomposable by this new body, with the disengagement of carbonic acid and oxygen. Brome seems, in the liquid way, capable of forming bromides of oxides, as of potash, &c. analogous to the chlorides of the same bases. When brome is put either by itself, or in its ethereous solution, into concentrated alkaline or earthy solutions, there is formed not only cubic crystals of the hydrobromates, but crystalline needles of bromates. It would appear, therefore, that brome exercises on the metals a less energetic action than chlorine, but one superior to iodine. The iodides are decomposed by brome, and the bromides in their turn by chlorine. Iodine, which decomposes readily potash and soda at an elevated temperature, does not act on barytes, with which it merely unites, forming an iodide of the earth. Brome, on the contrary, effects the decomposition of this base, and even of lime, but cannot act efficaciously on magnesia, which yields, however, to chlorine.

Brome combines with chlorine at ordinary temperatures. This compound may be procured by passing a current of chlorine gas through brome, and condensing the vapours disengaged by means of a freezing mixture. Chloride of brome appears under the form of a reddish-yellow liquid, much less deep than brome itself; of a brisk, penetrating odour, strongly exciting tears. Its taste is excessively disagreeable. It is fluid, and very volatile. Its vapours, of a dark yellow, similar to the colour of oxides of chlorine, have no resemblance to the ruddy hue of the vapours of brome.

It determines the combustion of metals, with which it probably forms chlorides and bromides.

It is soluble in water, producing a liquid possessing the peculiar colour and odour of the compound, and which rapidly blanches litmus paper without reddening it. The alkalis convert this chloride into hydrochlorates and hydrobromates.

Bromide of Iodine. Iodine seems susceptible of forming with brome two different compounds. When these two bodies are made to act on each other in certain proportions, a solid compound results, which produces, by heat, reddish-brown vapours, that condense into small crystals of the same colour, in form resembling leaves of fern. A new addition of brome transforms these crystals into a liquid compound, of an appearance similar to hydriodic acid strongly charged with iodine. Liquid bromide of iodine is miscible with water, to which it communicates the faculty of decolouring, without reddening, litmus paper. Alkalis poured into this solution give birth to hydrobromates and (hydr)iodates, as analogy indicates.

Bromide of Phosphorus. Phosphorus and brome put in contact in a flask filled with carbonic acid act suddenly on each other, with the production of heat and light. The resulting compound is divided into two portions; one solid, which sublimes into crystals in the upper part of the vessel; the other liquid remains below. This latter compound appears to contain less brome than the crystalline solid, for by adding more brome to the former it assumes this state.

The protobromide of phosphorus remains liquid even at a temperature of 10° Fahr. It feebly reddens litmus paper, an effect probably due to the materials not having been perfectly dry. It passes readily into vapour, diffusing in the air pungent vapours.

Like the proto-chloride, it can dissolve an excess of phosphorus, and thus acquire the property of setting fire to combustible bodies put in contact with it. It reacts on water with great energy, producing much heat, with a disengagement of hydrobromic acid, which may be received in a gaseous state when only a few drops of water have been used, but which remains dissolved in this liquid when more of it has been added. This acid solution subjected to evaporation leaves a residuum, which burns slightly when dried, and is thus converted into phosphoric acid.

The deuto-bromide of phosphorus is solid, and of a yellow colour. At a slightly elevated temperature it resolves itself into a red liquid, affording, by heat, vapours of the same hue. When the fused deuto-bromide is cooled, or when its vapours are condensed, in the first case, rhomboidal crystals are formed, and in the second, needles implanted on one another.

Metals decompose it, producing bromides, and probably phosphurets.

It diffuses in the air dense, pungent vapours. It effects the decomposition of water on the evolution of heat, and the production of hydrobromic and phosphoric acids.

When chlorine is made to act on either of these bromides of phosphorus, ruddy vapours of brome are exhaled, and chloride of phosphorus remains. Iodine cannot decompose these combinations. On the contrary, violet vapours, and some bromide, are obtained when brome acts on the iodide of phosphorus.

Bromide of Sulphur is obtained by pouring brome on sublimed sulphur. A liquid compound results of an oily appearance, of a reddish tint, deeper than that of chloride of sulphur, capable of diffusing like it, on contact with air, white vapours of a similar smell. Bromide of sulphur affects but feebly litmus paper; but with water it strongly reddens it. Water in the cold acts slowly on bromide of sulphur; but at the boiling temperature it produces a feeble detonation. Hydrobromic and sulphuric acids are formed along with sulphuretted hydrogen; whereas, in the same circumstances, chloride of sulphur would have produced, without any explosion, muriatic, sulphurous, and sulphuric acids. Bromide of sulphur is decomposed by chlorine, with disengagement of brome, and production of chloride of sulphur.

Hydro-carburet of Brome. Although carbon and brome have not apparently any tendency to combine, yet, on pouring a drop of brome into a flask filled with olefiant gas, it is instantly converted into a substance of an oily aspect heavier than water, colourless, and which presents no longer the lively odour of brome, but an ethereous smell more agreeable than that of the hydrocarburet of chlorine (chloric ether).

The hydro-carburet of brome is volatile, and is decomposed in traversing an ignited glass tube. In this experiment a deposit of charcoal falls, and hydrobromic acid escapes.

It burns on contact of a lighted taper, producing very acid vapours and dense smoke, consisting of finely divided charcoal. Bromide of carbon does not seem to form when the above hydro-carburet of brome is exposed to the sunbeams.

By distilling the mother water of salt springs, yellowed by chlorine, a similar hydro-carburet of brome is obtained, mixed with brome, which may be separated by the action of water. It happens occasionally that the whole brome is thus converted into hydro-carburet. This transformation is probably occasioned by the action of brome on a small quantity of organic matter which the springs contain, and which gives to the residuum of their evaporation the faculty of becoming black when strongly heated.

The great affinity which brome has for hydrogen enables us to anticipate its mode of action on organic bodies. It decomposes the greater part of them, with the production of hydrobromic acid, and the occasional precipitation of carbon.

Brome dissolves readily in acetic acid, on which it acts but slowly. It is very soluble in alcohol and ether. The coloured solutions which these two liquids form lose their tint at the end of a few days, when hydrobromic acid is found combined with the liquid.

The fixed oils have little effect on brome; but on pouring a few drops of this substance into a volatile oil, that of turpentine or aniseseed, for instance, heat is occasioned, white vapours of hydrobromic acid exhale, and the essential oil is converted into a resinous substance, of a yellowish colour, and tarry consistence, similar to turpentine.

Camphor dissolves in brome, forming a crystalline compound.

Brome is present in sea-water in very minute quantity. The mother water of salt springs (*salines*) even contains very little of it, though the concentration has been carried very far. It exists there probably in the state of hydrobromate of magnesia. Marine vegetables and animals also contain brome. The incinerated plants of the Mediterranean afford a yellow tint when the product of their lixiviation is treated with chlorine. Notable quantities of brome may be extracted from the mother waters of kelp that afford iodine. The best method of obtaining the brome from this compound matter, is to precipitate the iodine by a salt of copper, to separate by filtration the insoluble iodide of this metal, to evaporate the liquid, and to treat the residuum with sulphuric acid and manganese.—*Balard*, *Annales de Chim. et Phys.* xxxii. 337.

M. Sérullas has furnished some additional facts on *Brome*, in a memoir read to the Academy of Sciences on the 15th January, 1827.

Solidification of Brome. By plunging a tube containing some of it into a freezing mixture at —4° Fahr. the brome became instantly solid, and very hard, and it broke by a blow. He formed a hydro-carburet of brome, by projecting on it, in excess, a small quantity of hydriodide of carbon. The decomposition is instantaneous, with heat and a hissing noise. One part of brome is substituted for the iodine, combining with the carburetted hydrogen, furnishing an additional example of the displacement of iodine by brome. The hydrocarburet of brome, after washing with potash water, is colourless, very volatile, denser than water, of a penetrating ethereous smell, and a taste excessively saccharine, which it communicates to water poured over it, in which it is slightly soluble. Hydro-carburet of brome remains solid at a temperature of about 42° Fahr. It is then hard, and breaks like camphor.

Hydrobromic ether may be obtained nearly in the same way as hydriodic ether is prepared by M. Sérullas, viz. by acting on alcohol with phosphuret of iodine, to which a little iodine is successively added, by distilling off the alcohol and separating the ether which it holds in solution, by cold water.—*Annales de Chim. et de Phys.* xxv. 323.

Hydrobromic ether is colourless and transparent after long repose, denser than water, of a strong ethereous odour, a pungent taste, and very volatile. It does not change its colour, like hydriodic ether, by being kept under water.

Cyanide of brome was formed by putting two parts of cyanide of mercury into the sealed end of a glass tube, plunging this in iced water, and adding 1 part of brome. A lively action takes place with heat, and the cyanide crystallizes in long needles in the upper part of the tube. These may be distilled over into a cooled receiver-tube. It resembles very closely the cyanide of iodine, but is more volatile. It is also very poisonous, even in its vapour.

BRONZE. A mixed metal, consisting chiefly of copper, with a small proportion of tin, and sometimes other metals. It is used for casting statues, cannon, bells, and other articles, in all which the proportions of the ingredients vary.

BRONZITE. This massive mineral has a pseudo-metallic lustre, frequently resembling bronze. Its colour is intermediate between yellowish-brown and pinchbeck-brown. Lustre shining; structure lamellar with joints, parallel to the lateral planes of a rhomboidal prism; the fragments are streaked on the surface. It is opaque in mass, but transparent in thin plates. White streak; somewhat hard, but easily broken. Sp. gr. 3.2. It is composed of 60 silica, 27.5 magnesia, 10.5 oxide of iron, and 0.5 water. It is found in large masses in beds of serpentine, near Kraubat, in Upper Stiria; and in a syenitic rock in Glen Tilt, in Perthshire.

BROOKITE. In examining some well defined crystals from Snowdon, which had been classed by some with rutile, by others with sphene, M. Levy found a substance which certainly differs from both, its form being derivable from a right rhombic prism, while the primitive form of rutile is a square prism, and that of sphene an oblique rhombic prism. See figures of it in *Annals of Phil.* ix. 140.

BROWN SPAR. Pearl Spar, or Siderocalcite. It occurs massive, and in obtuse rhomboids with curvilinear faces. Its colours are white, red, and brown, or even pearl-grey and black. It is found crystallized in flat and acute double three-sided pyramids, in oblique six-sided pyramids, in lenses and rhombs. It is harder than calcareous spar, but yields to the knife. Its external lustre is shining, and internal pearly. Sp. gr. 2.88. Translucent, crystals semitransparent; it is easily broken into rhomboidal fragments. It effervesces slowly with acids. It is composed of 49.19 carbonate of lime, 44.39 carbonate of magnesia, 3.4 oxide of iron, and 1.5 manganese, by Hisinger's analysis. Klaproth found 32 carbonate of magnesia, 7.5 carbonate of iron, 2 carbonate of manganese, and 51.5 carbonate of lime.

There is a variety of this mineral of a fibrous texture, flesh-red colour, and massive.

BRUCIA, or BRUCINE. A new vegetable alkali, lately extracted from the bark of the false angustura, or *Brucia antidysenterica*, by MM. Pelletier and Caventou. After being treated with sulphuric ether, to get rid of a fatty matter, it was subjected to the action of alcohol. The dry residuum, from the evaporated alcoholic solution, was treated with Goulard's extract, or solution of subacetate of lead, to throw down the colouring matter, and the excess of lead was separated by a current of sulphuretted hydrogen. The nearly colourless alkaline liquid was saturated with oxalic acid, and evaporated to dryness. The saline mass being freed from its remaining colouring particles by absolute alcohol, was then decomposed by lime or magnesia, when the *brucia* was disengaged. It was dissolved in boiling alcohol, and obtained in crystals, by the slow evaporation of the liquid. These crystals, when obtained by very slow evaporation, are oblique prisms, the bases of which are parallelograms. When deposited from a saturated solution in boiling water, by cooling, it is in bulky plates, somewhat similar to boracic acid in appearance. It is soluble in 500 times its weight of boiling water, and in 850 of cold. Its solubility is much increased by the colouring matter of the bark.

Its taste is exceedingly bitter, acrid, and durable in the mouth. When administered in doses of a few grains, it is poisonous, acting on animals like strychnia, but much less violently. It is not affected by the air. The dry crystals fuse at a temperature a little above that of boiling water, and assume the appearance of wax. At a strong heat it is resolved into carbon, hydrogen, and oxygen; without any trace of azote. It combines with the acids, and forms both neutral and super-salts. Sulphate of brucia crystallizes in long slender needles, which appear to be four-sided prisms, terminated by pyramids of extreme fineness. It is very soluble in water, and moderately in alcohol. Its taste is very bitter. It is decomposed by potash, soda, ammonia, barytes, strontites, lime, magnesia, morphia, and strychnia. The bisulphate crystallizes more readily than the neutral sulphate. The latter is said to be composed of

Sulphuric acid,	8.84	5
Brucia,	91.16	51.582

Muriate of brucia forms in four-sided prisms, terminated at each end by an oblique face. It is permanent in the air, and very soluble in water. It is decomposed by sulphuric acid. Concentrated nitric acid destroys the alkaline bases of both these salts. The muriate consists of

Acid,	5.953	4.625
Brucia,	94.046	72.5

Phosphate of brucia is a crystallizable, soluble, and slightly efflorescent salt. The nitrate forms a gummy-looking mass; the binitrate crystallizes in acicular four-sided prisms. An excess of nitric acid decomposes the brucia into a matter of a fine red colour. Acetate and oxalate of brucia both crystallize. Brucia is insoluble in sulphuric ether, the fixed oils, and very slightly in the volatile oils. When administered internally, it produces tetanus, and acts upon the nerves without affecting the brain, or the intellectual faculties. Its intensity is to that of strychnia, as 1 to 12. From the discrepancies in the prime number for brucia, deduced from the above analyses, we see that its true equivalent remains to be determined. See *Journal de Pharmacie, Dec.* 1819.

BRUCITE, or CONDRODITE. This mineral occurs massive and in small grains, crossed by nearly parallel refts. Colour, wine, or wax-yellow; translucent; scratches glass with ease, and yields to the knife with difficulty. Sp. gr. 3.22, 3.55. By rubbing, it becomes negatively electric. It consists of magnesia 54, silica 38, oxide of iron 5.1, alumina 1.5, potash 0.86, manganese a trace. *Count d'Ohsson.* In the North American specimen, fluoric acid has been found to the amount of 4 *per cent.* It is found at Pargas, in Finland, and at Sparta, in New Jersey.

BRUNSWICK GREEN. This is an ammoniaco-muriate of copper, much used for paper-hangings, and on the continent in oil painting. See Copper.

BUCHOLZITE. This mineral is amorphous, spotted with white and black. Lustre glistening. Texture fibrous. It scratches glass, but is scratched by quartz. Its constituents are, silica 46, alumina 50, potash 1.5, oxide of iron, 2.5. *Brandes.* It is found in the Tyrol.

BUCKLANDITE. This mineral has hitherto been ranked with the pyroxenes, to which it has a great resemblance in form and external characters. Colour of the crystals, brown, nearly black, and opaque. They easily scratch glass, and seem harder than pyroxene. The forms of the crystals may be derived from an oblique rhombic prism.—*Mr. Levy in Annals of Philosophy, N. S.* vii. 134.

BUNTKUPFERERZ. Purple copper ore.

BUTTER. The oily inflammable part of milk, which is prepared in many countries as an article of food. The common mode of preserving it is by the addition of salt, which will keep it good a considerable time, if in sufficient quantity. Mr. Eaton informs us, in his Survey of the Turkish Empire, that most of the butter used at Constantinople is brought from the Crimea and Kirban, and that it is kept sweet, by melting it while fresh over a very slow fire, and removing the scum as it rises. He adds, that by melting butter in the Tartarian manner, and then salting it in ours, he kept it good and fine-tasted for two years; and that this melting, if carefully done, injures neither the taste nor colour. Thenard, too, recommends the Tartarian method. He directs the melting to be done on a water-bath, or at a heat not exceeding 180° Fahr.; and to be continued till all the caseous matter has subsided to the bottom, and the butter is transparent. It is then to be decanted, or strained through a cloth, and cooled in a mixture of pounded ice and salt, or at least in cold spring water, otherwise it will become lumpy by crystallizing, and likewise not resist the action of the air so well. Kept in a close vessel, and in a cool place, it will thus remain six months or more, nearly as good as at first, particularly after the top is taken off. If beaten up with one-sixth of its weight of the cheesy matter when used, it will in some degree resemble fresh butter in appearance. The taste of rancid butter, he adds, may be much corrected by melting and cooling in this manner.

Dr. Anderson has recommended another mode of curing butter, which is as follows: Take one part of sugar, one of nitre, and two of the best Spanish great salt, and rub them together into a fine powder. This composition is to be mixed thoroughly with the butter, as soon as it is completely freed from the milk, in the proportion of one ounce to sixteen; and the butter thus prepared is to be pressed tight into the vessel prepared for it, so as to leave no vacuities. This butter does not taste well, till it has stood at least a fortnight; it then has a rich marrow flavour, that no other butter ever acquires; and with proper care may be kept for years in this climate, or carried to the East Indies, if packed so as not to melt.

In the interior parts of Africa, Mr. Park informs us, there is a tree much resembling the American oak, producing a nut in appearance somewhat like an olive. The kernel of this nut, by boiling in water, affords a kind of butter, which is whiter, firmer, and of a richer flavour, than any he ever tasted made from cows' milk, and will keep without salt the whole year. The natives call it *shea toulou*, or tree butter. Large quantities of it are made every season.

BUTTER OF ANTIMONY. See Antimony.

BUTTER OF CACAO. An oily concrete white matter, of a firmer consistence than suet, obtained from the cacao nut, of which chocolate is made. The method of separating it consists in bruising the cacao and boiling it in water. The greater part of the superabundant and uncombined oil contained in the nut is by this means liquefied, and rises to the surface, where it swims, and is left to congeal, that it may be the more easily taken off. It is generally mixed with small pieces of the nut, from which it may be purified, by keeping it in fusion without water in a pretty deep vessel, until the several matters have arranged themselves according to their specific gravities. By this treatment it becomes very pure and white.

Butter of cacao is without smell, and has a very mild taste, when fresh; and in all its general properties and habitudes it resembles fat oils, among which it must therefore be classed. It is used as an ingredient in pomatums.

BUTTER OF TIN. See Tin.

BYSSOLITE. A massive mineral, in short and somewhat stiff filaments, of an olive-green colour, implanted perpendicularly like moss, on the surface of certain stones. It has been found at the foot of Mont Blanc, and also near Oisans on gneiss.

C

CABBAGE (RED). See BRASSICA RUBRA.

CACAO (BUTTER OF). See BUTTER.

CACHOLONG. A variety of quartz. It is opaque, dull on the surface, internally of a pearly lustre, brittle, with a flat conchoidal fracture, and harder than opal. Its colour is milk-white, yellowish, or greyish-white. It is not fusible before the blowpipe. Its sp. grav. is about 2.2. It is found in detached masses on the river Cach in Bucharia, in the trap rocks of Iceland, in Greenland, and the Feroe Islands. According to Brogniart, cacholongs are found also at Champigny near Paris, in the cavities of a calcareous breccia, some of which are hard and have a shining fracture, while others are tender, light, adhere to the tongue, and resemble chalk.

CADMIUM. A new metal first discovered by M. Stromeyer, in the autumn of 1817, in some carbonate of zinc which he was examining in Hanover. It has been since found in the Derbyshire silicates of zinc.

The following is Dr. Wollaston's process for procuring cadmium. It is distinguished by the usual elegance and precision of the analytical methods of this philosopher. From the solution of the salt of zinc supposed to contain cadmium, precipitate all the other metallic impurities by iron; filter and immerse a cylinder of zinc into the clear solution. If cadmium be present, it will be thrown down in the metallic state, and when redissolved in muriatic acid, will exhibit its peculiar character on the application of the proper tests.

M. Stromeyer's process consists in dissolving the substance which contains cadmium in sulphuric acid, and passing through the acidulous solution a current of sulphuretted hydrogen gas. He washes this precipitate, dissolves it in concentrated muriatic acid, and expels the excess of acid by evaporation. The residue is then dissolved in water, and precipitated by carbonate of ammonia, of which an excess is added, to redissolve the zinc and the copper that may have been precipitated by the sulphuretted hydrogen gas. The carbonate of cadmium being well washed, is heated, to drive off the carbonic acid, and the remaining oxide is reduced by mixing it with lampblack, and exposing it to a moderate red heat in a glass or earthen retort.

The colour of cadmium is a fine white, with a slight shade of bluish-grey, approaching much to that of tin; which metal it resembles in lustre and susceptibility of polish. Its texture is compact, and its fracture hackly. It crystallizes easily in octohedrons, and presents on its surface, when cooling, the appearance of leaves of fern. It is flexible, and yields readily to the knife. It is harder and more tenacious than tin; and, like it, stains paper, or the fingers. It is ductile and malleable, but when long hammered, it scales off in different places. Its sp. grav. before hammering, is 8.6040; and when hammered, it is 8.6944. It melts, and is volatilized under a red heat. Its vapour, which has no smell, may be condensed in drops like mercury, which, on congealing, present distinct traces of crystallization.

Cadmium is as little altered by exposure to the air as tin. When heated in the open air, it burns like that metal, passing into a smoke, which falls and forms a very fixed oxide, of a brownish-yellow colour. Nitric acid readily dissolves it cold; dilute sulphuric, muriatic, and even acetic acids, act feebly on it with the disengagement of hydrogen. The solutions are colourless, and are not precipitated by water.

Cadmium forms a single oxide, in which 100 parts of the metal are combined with 14.352 of oxygen. The prime equivalent of cadmium deduced from this compound seems to be very nearly 7, and that of the oxide 8. This oxide varies in its appearance according to circumstances from a brownish-yellow to a dark brown, and even a blackish colour. With charcoal it is reduced with rapidity below a red heat. It gives a transparent colourless glass bead with borax. It is insoluble in water, but in some circumstances forms a white hydrate, which speedily attracts carbonic acid from the air, and gives out its water when exposed to heat.

The fixed alkalis do not dissolve the oxide of cadmium in a sensible degree; but liquid ammonia readily dissolves it. On evaporating the solution, the oxide falls in a dense gelatinous hydrate. With the acids it forms salts, which are almost all colourless, have a sharp metallic taste, are generally soluble in water, and possess the following characters:

1. The fixed alkalis precipitate the oxide in the state of a white hydrate. When added in excess, they do not redissolve the precipitate, as is the case with the oxide of zinc.

2. Ammonia likewise precipitates the oxide white, and doubtless in the state of hydrate; but an excess of the alkali immediately redissolves the precipitate.

3. The alkaline carbonates produce a white precipitate, which is an anhydrous carbonate. Zinc in the same circumstances gives a hydrous carbonate. The precipitate formed by the carbonate of ammonia is not soluble in an excess of this solution. Zinc exhibits quite different properties.

4. Phosphate of soda exhibits a white pulverulent precipitate. The precipitate formed by the same salt in solutions of zinc, is in fine crystalline plates.

5. Sulphuretted hydrogen gas, and the hydrosulphurets, precipitate cadmium yellow or orange. This precipitate resembles orpiment a little in colour, with which it might be confounded without sufficient attention. But it may be distinguished by being more pulverulent, and precipitating more rapidly. It differs particularly in its easy solubility in muriatic acid, and in its fixity.

6. Ferroprussiate of potash precipitates solutions of cadmium white.

7. Nutgalls do not occasion any change.

8. Zinc precipitates cadmium in the metallic state in the form of dendritical leaves, which attach themselves to the zinc.

The carbonate consists, by Stromeyer, of

Acid,	100.00	25.4	2.750
Oxide	292.88	74.6	8.054

The sulphate crystallizes in large rectangular transparent prisms, similar to sulphate of zinc, and very soluble in water. It effloresces in the air. At a strong red heat it gives out a portion of its acid, and becomes a subsulphate, which crystallises in plates that dissolve with difficulty in water. The neutral sulphate consists of,

Acid,	100.00	38.3	5.000
Oxide,	161.12	61.7	8.056

100 parts of the salt take 34.26 of water of crystallization. Nitrate of cadmium crystallises in prisms or needles, usually grouped in rays. It is deliquescent. Its constituents are,

Acid,	100.00	46	6.75000
Oxide,	117.58	54	7.93665

100 parts of the dry salt take 28.31 water of crystallization. The muriate of cadmium crystallizes in small rectangular prisms, perfectly transparent, which effloresce easily when heated, and which are very soluble. It melts under a red heat, loses its water of crystallization, and on cooling assumes the form of a foliated mass, which is transparent, and has a lustre slightly metallic and pearly. In the air it speedily loses its transparency, and falls down in a white powder. 100 parts of fused chloride are composed of,

Cadmium,	61.39	7.076
Chlorine,	58.61	4.450

Phosphate of cadmium is pulverulent, insoluble in water, and melts, when heated to redness, into a transparent vitreous body. It is composed of,

Acid,	100	3.54
Oxide,	225.49	8.00

Borate of cadmium is scarcely soluble in water. It consists of,

Acid,	27.88	3.079
Oxide,	72.12	8.000

Acetate of cadmium crystallizes in small prisms, usually disposed in stars, which are not altered by exposure to air, and are very soluble in water. The tartrate crystallizes in small scarcely soluble needles. The oxalate is insoluble. The citrate forms a crystalline powder, very little soluble.

100 parts of cadmium unite with 28.172 of sulphur, to form a sulphuret of a yellow colour, with a shade of orange. It is very fixed in the fire. It melts at a white red heat, and on cooling, crystallizes in micaceous plates of the finest lemon-yellow colour. The sulphuret dissolves even cold in concentrated muriatic acid, with the disengagement of sulphuretted hydrogen gas; but the dilute acid has little effect on it, even with the assistance of heat. It is best formed by heating together a mixture of sulphur with the oxide, or by precipitating a salt of cadmium with sulphuretted hydrogen. It promises to be useful in painting.

Phosphuret of cadmium, made by fusing the ingredients together, has a grey colour, and a lustre feebly metallic. Muriatic acid decomposes it, evolving phosphuretted hydrogen gas. Iodine unites with cadmium, both in the moist and dry way. We obtain an iodide in large and beautiful hexahedral tables. These crystals are colourless, transparent, and not altered by exposure to air. Their lustre is pearly, approaching to metallic. It melts with extreme facility, and assumes, on cooling, the original form. At a high temperature, it is resolved into cadmium and iodine. Water and alcohol dissolve it with facility. It is composed of

Cadmium,	100.00	7.000
Iodine,	227.43	15.9

Cadmium unites easily with most of the metals, when heated along with them out of contact of air. Most of its alloys are brittle and colourless. That of copper and cadmium is white, with a slight tinge of yellow. Its texture is composed of very fine plates. $\frac{1}{100}$ of cadmium communicates a good deal of brittleness to copper. At a strong heat the cadmium flies off. Tutty usually contains oxide of cadmium. The alley consists of,

Copper,	100
Cadmium,	84.2

The alloy of cobalt and cadmium has a good deal of resemblance to arsenical cobalt. Its colour is almost silver-white. 100 parts of platinum combine with 117.3 of cadmium. Cadmium and mercury readily unite cold, into a fine silver-white amalgam, of a granular texture, which may be crystallized in octohedrons. Its specific gravity is greater than that of mercury. It fuses at 167° F. It consists of,

Mercury,	100
Cadmium,	27.78

Dr. Clarke found in 100 gr. of the fibrous silicate of zinc, of Derbyshire, about 6-10ths of a grain of sulphuret of cadmium; a result which agrees with the experiments of Dr. Wollaston and Mr. Children.

Mr. W. Herapath states, that he has obtained cadmium in abundance from the zinc works near Bristol. Zinc is obtained by putting calamine with small coal into a crucible, which being closed at top, has a tube proceeding through its bottom into a vault below. Beneath the tube is a vessel of water. A short tube is at hand to connect, at a proper time, with the long one, so as almost to reach the water. The workmen do not complete the connexion till the "brown blaze" is over, and the "blue blaze" begun. This brown flame is owing to cadmium, the oxide of which attaches itself to the roof of the vault, in greatest quantity, just over the orifice. It is mixed with soot, sulphuret of cadmium, and oxide of zinc. Some portions contain from 12 to 20 per cent. of cadmium. The metal is obtained by dissolving this substance in muriatic acid, filtering, evaporating to dryness, redissolving and filtering, then precipitating by a plate of zinc. The cadmium thrown down is to be mixed with a little lamp-black or wax, put into a black or green glass tube, and placed in the red heat of a common fire, until the cadmium has sublimed into the cool part of the tube; then the residuum is to be shaken out, which is easily done without loss of cadmium. A little wax introduced into the tube, and a gentle heat applied, the metal melts, and by agitation forms a button.

Mr. Herapath thinks, that if the zinc smelter were to insert his tube earlier, and condense the first few pounds of metal separate, he would be able to collect abundance of cadmium, so as to afford it cheaply for the purposes of art. *Ann. of Phil.* iii. 435.

CAFEIN. By adding muriate of tin to an infusion of unroasted coffee, M. Chenevix obtained a precipitate, which he washed and decomposed by sulphuretted hydrogen. The supernatant liquid contained a peculiar bitter principle, which occasioned a green precipitate in concentrated solutions of iron. When the liquid was evaporated to dryness, it was yellow and transparent, like horn. It did not attract moisture from the air, but was soluble in water and alcohol. The solution had a pleasant bitter taste, and assumed with alkalis a garnet-red colour. It is almost as delicate a test of iron as infusion of galls is; yet gelatine occasions no precipitate with it.

M. Robiquet, while searching for quinina in coffee, discovered a crystallizable principle in it, in the year 1821. It is white, crystalline, volatile, and slightly soluble. Its composition is very remarkable, for according to MM. Dumas and Pelletier, it consists of

Carbon	46.51
Nitrogen	21.54
Hydrogen	4.81
Oxygen	27.14
	100.00

The quantity of nitrogen in it surpasses that not only in vegetable, but in most animal substances; and must excite doubts as to the accuracy of the analysis. *Ann. de Chim.* xxiv. 183.

CAJEPUT OIL. The volatile oil obtained from the leaves of the cajeput tree, Cajeputa officinarum, the Melaleuca Leucadendron of Linnæus. The tree which furnishes the cajeput oil is frequent on the mountains of Amboyna, and other Molucca islands. It is obtained by distillation from the dried leaves of the smaller of two varieties. It is prepared in great quantities, especially in the island of Banda, and sent to Holland in copper flasks. As it comes to us, it is of a green colour, very limpid, lighter than water, of a strong smell resembling camphor, and a strong pungent taste, like that of cardamoms. It burns entirely away, without leaving any residuum. It is often adulterated with other essential oils, coloured with the resin of milfoil. In the genuine oil, the green colour depends on the presence of copper; for when rectified it is colourless.

CALAMINE. A native carbonate of zinc.

CALAMITE. A mineral which occurs in rhombic prisms of a light green colour, translucent, striated longitudinally, and yielding to mechanical division readily, parallel to the sides of a rhombic prism. It is soft; resembling tremolite in the form of its crystal. It is found in serpentine with magnetic iron and calcareous spar, near Normark, in Sweden. *Phillips's Mineralogy.*

CALCAREOUS EARTH. See LIME.

CALCAREOUS SPAR. Crystallized carbonate of lime. It occurs crystallized in more than 600 different forms, all having for their primitive form an obtuse rhomboid, with angles of 74° 55′ and 105° 5′. It occurs also massive, and in imitative shapes. Werner has given a comprehensive idea of the varieties of the crystals, by referring all the forms to the six-sided pyramid, the six-sided prism, and the three-sided prism, with their truncations. The colours of calc-spar are grey, yellow, red, green, and rarely blue. Vitreous lustre. Foliated fracture, with a threefold cleavage. Fragments rhomboidal. Transparent, or translucent. The transparent crystals refract double. It is less hard than fluor spar, and is easily broken. Sp. gr. 2.7. It consists of 43.6 carbonic acid, and 56.4 lime. It effervesces powerfully with acids. Some varieties are phosphorescent on hot coals. It is found in veins in all rocks, from granite to alluvial strata, and sometimes in strata between the beds of calcareous mountains. The rarest and most beautiful crystals are found in Derbyshire; but it exists in every part of the world.

CALCEDONY. A mineral so called from Calcedon in Asia Minor, where it was found in ancient times. There are several sub-species: common calcedony, heliotrope, chrysoprase, plasma, onyx, sard, and sardonyx.

Common calcedony occurs in various shades of white, grey, yellow, brown, green, and blue. The blackish-brown appears, on looking through the mineral, to become a blood-red. It is found in nodules; botroidal stalactitical, bearing organic impressions, in veins, and also massive. Its fracture is even, sometimes flat conchoidal, or fine splintery. Semitransparent, harder and tougher than flint. Sp. grav. 2.6. It is not fusible. It may be regarded as pure silica, with a minute portion of water. Very fine stalactitical specimens have been found in Trevascus mine in Cornwall. It occurs in the toadstone of Derbyshire, in the trap rocks of Fifeshire, of the Pentland-hills, Mull, Rum, Sky, and others of the Scottish Hebrides; likewise in Iceland, and the Ferro Islands. See the sub-species, under their respective titles.

CALC SINTER. Stalactitical carbonate of lime. It is found in pendulous conical rods or tubes, mamellated, massive, and in many imitative shapes. Fracture lamellar, or divergent fibrous. Lustre silky or pearly. Colours white, of various shades, yellow, brown, rarely green, passing into blue or red. Translucent —semihard—very brittle. Large stalactites are found in the grotto of Antiparos, the woodman's cave in the Hartz, the cave of Auxelle in France, in the cave of Castleton in Derbyshire, and Macalister cave in Sky. They are continually forming by the infiltration of carbonated lime water, through the crevices of the roofs of caverns. Solid masses of stalactite have been called oriental alabaster. The irregular masses on the bottoms of caves have been called stalagmites.

CALCHANTUM. Pliny's term for copperas.

CALCINATION. The fixed residues of such matters as have undergone combustion are called cinders in common language, and calces, or now more commonly oxides, by chemists; and the operation, when considered with regard to these residues, is termed calcination. In this general way it has likewise been applied to bodies not really combustible, but only deprived of some of their principles by heat. Thus we hear of the calcination of chalk, to convert it into lime, by driving off its carbonic acid and water: of gypsum or plaster stone, of alum, of borax, and other saline bodies, by which they are deprived of their water of crystallization; of bones, which lose their volatile parts by this treatment; and of various other bodies. See COMBUSTION and OXIDATION.

CALCIUM. The metallic basis of lime. Sir H. Davy, the discoverer of this metal, procured it by the process which he used for obtaining *barium;* which see. It was in such small quantities, that little could be said concerning its nature. It appeared brighter and whiter than either barium or strontium; and burned when gently heated, producing dry lime.

There is only one known combination of calcium and oxygen, which is the important substance called lime. The nature of this substance is proved by the phenomena of the combustion of calcium; the metal changing into the earth with the absorption of oxygen gas. When the amalgam of calcium is thrown into water, hydrogen gas is disengaged, and the water becomes a solution of lime. From the quantity of hydrogen evolved, compared with the quantity of lime formed in experiments of this kind, M. Berzelius endeavoured to ascertain the proportion of oxygen in lime. The nature of lime may also be proved by analysis. When potassium in vapour is sent through the earth ignited to whiteness, the potassium was found by Sir H. Davy to become potash, while a dark grey substance of metallic splendour, which is calcium, either wholly or partially deprived of oxygen, is found imbedded in the potash, for it effervesces violently, and forms a solution of lime by the action of water.

Lime is usually obtained forc hemical purposes, from marble of the whitest kind, or from calcareous spar, by long exposure to a strong red heat. It is a soft white substance, of specific gravity 2.3. It requires an intense degree of heat for its fusion; and has not hitherto been volatilised. Its taste is caustic, astringent and alkaline. It is soluble in 450 parts of water, according to Sir H. Davy; and in 760 parts, according to other chemists. The solubility is not increased by heat. If a little water only be sprinkled on new burnt lime, it is rapidly absorbed, with the evolution of much heat and vapour. This constitutes the phenomenon called slaking. The heat proceeds, according to Dr. Black's explanation, from the consolidation of the liquid water into the lime, forming a *hydrate*, as slaked lime is now called. It is a compound of 3.5 parts of lime, with 1.125 of water; or very nearly 3 to 1. This water may be expelled by a red heat, and therefore does not adhere to lime with the same energy as it does to barytes and strontites. Lime water is astringent and somewhat acrid to the taste. It renders vegetable blues green; the yellows brown; and restores to reddened litmus its usual purple. When lime water stands exposed to the air, it gradually attracts carbonic acid, and becomes an insoluble carbonate, while the water remains pure. 'If lime water be placed in a capsule under an exhausted receiver, which also encloses a saucer filled with concentrated sulphuric acid, the water will be gradually withdrawn from the lime, which will concrete into small six-sided prismatic crystals.

Berzelius attempted to determine the prime equivalent of calcium, from the proportion in which it combines with oxygen to form lime; but his results can be regarded only as approximations, in consequence of the difficulties of the experiment. The prime equivalent of lime, or oxide of calcium, can be determined very exactly. 100 parts of carbonate of lime, consist of 44 carbonic acid + 56 lime; whence the prime equivalent proportions are, 2.75 acid + 3.5 base.

If a piece of phosphorus be put into the sealed end of a glass tube, the middle part of which is filled with bits of lime about the size of peas; and after the latter is ignited, if the former be driven through it in vapour, by heating the end of the tube, a compound of a dark brown colour, called phosphuret of lime, will be formed. This probably consists of 1.5 phosphorus + 2.5 calcium; but it has not been exactly analysed. When thrown into water, phosphuretted hydrogen gas is disengaged in small bubbles, which explode in succession as they burst.

Sulphuret of lime is formed by fusing the constituents mixed together in a covered crucible. The mass is reddish coloured and very acrid. It deliquesces on exposure to air, and becomes of a greenish yellow hue. When it is put into water, a hydroguretted sulphuret of lime is immediately formed. The same liquid compound may be directly made, by boiling a mixture of sulphur and lime in water. It acts corrosively on animal bodies, and is a powerful reagent in precipitating metals from their solutions. Solid sulphuret of lime probably consists of 2 sulphur + 2.5 calcium.

When lime is heated strongly in contact with chlorine, oxygen is expelled, and the chlorine is absorbed. For every two parts in volume of chlorine that disappear, one of oxygen is obtained. When liquid muriate of lime is evaporated to dryness, and ignited, it forms the same substance, or chloride of lime. It is a semitransparent crystalline substance; fusible at a strong red heat; a nonconductor of electricity; has a very bitter taste; rapidly absorbs water from the atmosphere; and is extremely soluble in water. See ACID (MURIATIC). It consists of 2.5 calcium + 4.5 chlorine = 7.0. Chlorine combines also with oxide of calcium or lime, forming the very important substance used in bleaching, under the name of oxymuriate of lime; but which is more correctly called chloride of lime. See LIME, (CHLORIDE of).

Under LIME, some observations will be found on the uses of this substance.

If the liquid hydriodate of lime be evaporated to dryness, and gently heated, an iodide of calcium remains. It has not been applied to any use.

CALCTUFF. An alluvial formation of carbonate of lime, probably deposited from calcareous springs. It has a yellowish-grey colour; a dull lustre internally; a fine grained earthy fracture; is opaque, and usually marked with impressions of vegetable matter. Its specific gravity is nearly the same with that of water. It is soft, and easily cut or broken.

CALCULUS, *or* **STONE.** This name is generally given to all hard concretions, not bony, formed in the bodies of animals. Of these, the most important, as giving rise to one of the most painful diseases incident to human nature, is the *urinary calculus*, or stone in the bladder. Different substances occasionally enter into the composition of this calculus, but the most usual is the lithic acid.

If we except Scheele's original observations concerning the uric or lithic acid, all the discoveries relating to urinary concretions are due to Dr. Wollaston; discoveries so curious and important, as alone are sufficient to entitle him to the admiration and gratitude of mankind. They have been fully verified by the subsequent researches of MM. Fourcroy, Vauquelin, and Brande, Drs. Henry, Marcet, and Prout. Dr. Marcet, in his late valuable essay on the chemical history and medical treatment of calculous disorders, arranges the concretions into nine species.

1. The lithic acid calculus.
2. The ammonia-magnesian phosphate calculus.
3. The bone earth calculus, or phosphate of lime.
4. The fusible calculus, a mixture of the 2d and 3d species.
5. The mulberry calculus, or oxalate of lime.
6. The cystic calculus; cystic oxyde of Dr. Wollaston.
7. The alternating calculus, composed of alternate layers of different species.
8. The compound calculus, whose ingredients are so intimately mixed, as to be separable only by chemical analysis.
9. Calculus from the prostate gland, which, by Dr. Wollaston's researches, is proved to be phosphate of lime, not distinctly stratified, and tinged by the secretion of the prostate gland.

To the above Dr. Marcet has added two new sub-species. The first seems to have some resemblance to the cystic oxide, but it possesses also some marks of distinction. It forms a bright lemon-yellow residuum on evaporating its nitric acid solution, and is composed of laminæ. But the cystic oxide is not laminated, and it leaves a white residuum from the nitric acid solution. Though they are both soluble in acids as well as alkalis, yet the oxide is more so in acids than the new calculus, which has been called by Dr. Marcet, from its yellow residuum, *xanthic* oxide. Dr. Marcet's other new calculus was found to possess the properties of the fibrine of the blood, of which it seems to be a deposite. He terms it *fibrinous* calculus.

Species 1. Uric acid calculi. Dr. Henry says, in his instructive paper on urinary and other morbid concretions, read before the Medical Society of London, March 2, 1819, that it has never yet occurred to him to examine calculi composed of this acid in a state of absolute purity. They contain about 9-10ths of the pure acid, along with urea, and an animal matter which is not gelatine, but of an albuminous nature. This must not, however, be regarded as a cement. The calculus is aggregated by the cohesive attraction of the lithic acid itself. The colour of lithic acid calculi is yellowish or reddish-brown, resembling the appearance of wood. They have commonly a smooth polished surface, a lamellar or radiated structure, and consist of fine particles well compacted. Their sp. gravity varies from 1.3 to 1.8. They dissolve in alkaline lixivia, without evolving an ammoniacal odour, and exhale the smell of horn before the blowpipe. The relative frequency of lithic acid calculi will be seen from the following statement. Of 150 examined by Mr. Brande, 16 were composed wholly of this acid, and almost all contained more or less of it. Fourcroy and Vauquelin found it in the greater number of 500 which they analyzed. All those examined by Scheele consisted of it alone; and 300 analyzed by Dr. Pearson, contained it in greater or smaller proportion. According to Dr. Henry's experience, it constitutes 10 urinary concretions out of 26, exclusive of the alternating calculi. And Mr. Brande lately states, that out of 58 cases of *kidney* calculi, 51 were lithic acid, 6 oxalic, and 1 cystic.

Species 2. Ammonia-magnesian phosphate. This calculus is white like chalk, is friable between the fingers, is often covered with dog-tooth crystals, and contains semi-crystalline layers. It is *insoluble* in alkalis, but soluble in nitric, muriatic, and acetic acids. According to Dr. Henry, the earthy phosphates, comprehending the 2d and 3d species, were to the whole number of concretions, in the ratio of 10 to 85. Mr. Brande justly observes, in the 16th number of his Journal, that the urine has at all times a tendency to deposit the triple phosphate upon any body over which it passes. Hence drains by which urine is carried off, are often incrusted with its regular crystals; and in cases where extraneous bodies have got into the bladder, they have often in a very short time become considerably enlarged by deposition of the same substance. When this calculus, or those incrusted with its semi-crystalline particles, are strongly heated before the blowpipe, ammonia is evolved, and an imperfect fusion takes place. When a little of the calcareous phosphate is present, however, the concretion readily fuses. Calculi composed *entirely* of the ammonia-magnesian phosphate are very rare. Mr. Brande has seen only two. They were crystallized upon the surface, and their fracture was somewhat foliated. In its pure state, it is even rare as an incrustation. The powder of the ammonia-phosphate calculus has a brilliant white colour, a faint sweetish taste, and is somewhat soluble in water. Fourcroy and Vauquelin suppose the above deposites to result from incipient putrefaction of urine in the bladder. It is certain that the triple phosphate is copiously precipitated from urine in such circumstances out of the body.

Species 3. The bone earth calculus. Its surface, according to Dr. Wollaston, is generally pale brown, smooth, and when sawed through it appears of a laminated texture, easily separable into concentric crusts. Sometimes, also, each lamina is striated in a direction perpendicular to the surface, as from an assemblage of crystalline needles. It is difficult to fuse this calculus by the blowpipe, but it dissolves readily in dilute muriatic acid, from which it is precipitable by ammonia. This species, as described by Fourcroy and Vauquelin, was white, without lustre, friable, staining the hands, paper, and cloth. It had much of a chalky appearance, and broke under the forceps, and was intimately mixed with a gelatinous matter, which is left in a membranous form, when the earthy salt is withdrawn by dilute muriatic acid. Dr. Henry says that he has never been able to recognize a calculus of pure phosphate of lime, in any of the collections which he has examined; nor did he ever find the preceding species in a pure state, though a calculus in Mr. White's collection contained more than 90 per cent. of ammonia-magnesian phosphate.

Species 4. The fusible calculus. This is a very friable concretion, of a white colour, resembling chalk in appearance and texture; it often breaks into layers, and exhibits glittering appearance internally, from intermixture of the crystals of triple phosphate. Sp. grav. from 1.14 to 1.47. Soluble in dilute muriatic and nitric acids, but not in alkaline lixivia. The nucleus is generally lithic acid. In 4 instances only out of 187, did Dr. Henry find the calculus composed throughout of the earthy phosphates. The analysis of fusible calculus is easily performed by distilled vinegar, which at a gentle heat dissolves the ammonia-magnesian phosphate, but not the phosphate of lime; the latter may be taken up by dilute muriatic acid. The lithic acid present will remain, and may be recognized by its solubility in the water of pure potash or soda. Or the lithic acid may, in the first instance, be removed by the alkali, which expels the ammonia, and leaves the phosphate of magnesia and lime.

Species 5. The mulberry calculus. Its surface is rough and tuberculated; colour deep reddish-brown. Sometimes it is pale brown, of a crystalline texture, and covered with flat octohedral crystals. This calculus has commonly the density and hardness of ivory, a sp. grav. from 1.4 to 1.98, and exhales the odour of semen when sawed. A moderate red heat converts it into carbonate of lime. It does not dissolve in alkaline lixivia, but slowly and with difficulty in acids. When the oxalate of lime is voided directly after leaving the kidney, it is of a greyish-brown colour, composed of small cohering spherules, sometimes with a polished surface resembling hempseed. They are easily recognized by their insolubility in muriatic acid, and their swelling up and passing into pure lime before the blowpipe. Mulberry calculi contain always an admixture of other substances besides oxalate of lime. These are, uric acid, phosphate of lime, and animal matter in dark flocculi. The colouring matter of these calculi is probably effused blood. Dr. Henry rates the frequency of this species at 1 in 17 of the whole which he has compared; and out of 187 calculi, he found that 17 were formed round *nuclei* of oxalate of lime.

Species 6. The cystic-oxide calculus. It resembles a little the triple phosphate, or more exactly magnesian limestone. It is somewhat tough when cut, and has a peculiar greasy lustre. Its usual colour is pale brown, bordering on straw-yellow; and its texture is irregularly crystalline. It unites in solution with acids and alkalis, crystallising with both. Alcohol precipitates it from nitric acid. It does not become red with nitric acid; and it has no effect upon vegetable blues. Neither water, alcohol, nor ether dissolves it. It is decomposed by heat into carbonate of ammonia and oil, leaving a minute residuum of phosphate of lime. This concretion is of very rare occurrence. Dr. Henry states its frequency to the whole as 10 to 985. In two which he examined, the nucleus was the same substance with the rest of the concretion; and in a third, the nucleus of an uric acid calculus was a small spherule of cystic oxide. Hence, as Dr. Marcet has remarked, this oxide appears to be in reality the production of the kidneys, and not, as its name would import, to be generated in the bladder. It might be called with propriety *renal* oxide, if its eminent discoverer should think fit.

Species 7. The alternating calculus. The surface of this calculus is usually white like *chalk*, and friable or semicrystalline, according as the exterior coat is the calcareous or ammonia-magnesian phosphate. They are frequently of a large size, and contain a nucleus of lithic acid. Sometimes the two phosphates form alternate layers round the nucleus. The above are the most common alternating calculi; next are those of oxalate of lime with phosphates; then oxalate of lime with lithic acid; and, lastly, those in which the three substances alternate. The alternating, taken all together, occur in 10 out of 25, in Dr. Henry's list; the lithic acid with phosphates, as 10 to 48; the oxalate of lime with phosphates, as 10 to 116; the oxalate of lime with lithic acid, as 10 to 170; the oxalate of lime with lithic acid and phosphates, as 10 to 265.

Species 8. The compound calculus. This consists of a mixture of lithic acid with the phosphates in variable proportions, and is consequently variable in its appearance. Sometimes the alternating layers are so thin as to be undistinguishable by the eye, when their nature can be determined only by chemical analysis. This species, in Dr. Henry's list, forms 10 in 235. About 1-40th of the calculi examined by Fourcroy and Vanquelin were compound.

Species 9. has been already described.

In almost all calculi, a central nucleus may be discovered, sufficiently small to have descended through the ureters into the bladder. The disease of stone is to be considered, therefore, essentially and originally as belonging to the kidneys. Its increase in the bladder may be occasioned, either by exposure to urine that contains an excess of the same ingredient as that composing the nucleus, in which case it will be uniformly constituted throughout; or if the morbid nucleus deposite should cease, the concretion will then acquire a coating of the earthy phosphates. It becomes, therefore, highly important to ascertain the nature of the most predominant nucleus. Out of 187 calculi examined by Dr. Henry, 17 were formed round nuclei of oxalate of lime; 3 round nuclei of cystic oxide; 4 round nuclei of the earthy phosphates; 2 round extraneous substances; and in 3 the nucleus was replaced by a small cavity, occasioned probably by the shrinking of some animal matter, round which the ingredients of the calculi (fusible) had been deposited. Rau has shown by experiment, that pus may form the nucleus of an urinary concretion. The remaining 158 calculi of Dr. Henry's list, had central nuclei composed chiefly of lithic acid. It appears, also, that in a very great majority of the cases referred to by him, the disposition to secrete an excess of lithic acid has been the essential cause of the origin of stone. Hence it becomes a matter of great importance to inquire, what are the circumstances which contribute to its excessive production, and to ascertain by what plan of diet and medicine this morbid action of the kidneys may best be obviated or removed. A calculus in Mr. White's collection had for its nucleus a fragment of a bougie, that had slipped into the bladder. It belonged to the fusible species, consisting of,

20	phosphate of lime
60	ammonia-magnesian phosphate
10	lithic acid
10	animal matter
100	

In some instances, though these are comparatively very few, a morbid secretion of the earthy phosphates in excess, is the cause of the formation of stone. Dr. Henry relates the case of a gentleman, who, during paroxysms of gravel, preceded by severe sickness and vomiting, voided urine as opaque as milk, which deposited a great quantity of an impalpable powder, consisting of the calcareous and triple phosphate in nearly equal proportions. The weight of the body was rapidly reduced from 188 to 100 pounds, apparently by the abstraction of the earth of his bones; for there was no emaciation of the muscles corresponding to the above diminution.

The first rational views on the treatment of calculous disorders, were given by Dr. Wollaston. These have been followed up lately by some very judicious observations of Mr. Brande in the 12th, 15th, and 16th numbers of his Journal; and also by Dr. Marcet, in his excellent treatise already referred to. Of the many substances contained in human urine, there are rarely more than three which constitute gravel; viz. calcareous phosphate, ammonia-magnesian phosphate, and lithic acid. The former two form a white sediment; the latter, a red or brown. The urine is always an acidulous secretion. Since by this excess of acid, the earthy salts, or white matter, are held in solution, whatever disorder of the system, or impropriety of food and medicine, diminishes that acid excess, favours the formation of white deposite. The internal use of acids was shown by Dr. Wollaston to be the appropriate remedy in this case.

White gravel is frequently symptomatic of disordered digestion, arising from excess in eating or drinking; and it is often produced by too farinaceous a diet. It is also occasioned by the indiscreet use of magnesia, soda water, or alkaline medicines in general. Medical practitioners, as well as their patients, ignorant of chemistry, have often committed fatal mistakes, by considering the white gravel, passed on the administration of alkaline medicines, as the dissolution of the calculus itself; and have hence pushed a practice, which has rapidly increased the size of the stone. Magnesia, in many cases, acts more injuriously than alkali, in precipitating insoluble phosphate from the urine. The acids of urine, which, by their excess, hold the earths in solution, are the phosphoric, lithic, and carbonic. Mr. Brande has uniformly obtained the latter acid, by placing urine under an exhausted receiver; and he has formed carbonate of barytes, by dropping barytes water into urine recently voided.

The appearance of white sand does not seem deserving of much attention, where it is merely occasional, following indigestion brought on by an accidental excess. But if it invariably follows meals, and if it be observed in the urine, not as a mere deposite, but at the time the last drops are voided, it becomes a matter of importance, as the forerunner of other and serious forms of the disorder. It has been sometimes viewed as the *effect* of irritable bladder, where it was in reality the *cause*. Acids are the proper remedy, and unless some peculiar tonic effect be sought for in sulphuric acid, the vegetable acids ought to be preferred. Tartar, or its acid, may be prescribed with advantage, but the best medicine is citric acid, in daily doses of from 5 to 30 grains. Persons returning from warm climates, with dyspeptic and hepatic disorders, often void this white gravel, for which they have recourse to empirical solvents, for the most part alkaline, and are deeply injured. They ought to adopt an acidulous diet, abstaining from soda water, alkalis, malt liquor, madeira and port; to eat salads, with acid fruits; and if habit requires it, a glass of cider, champagne or claret, but the less of these fermented liquors the better. An effervescing draught is often very beneficial, made by dissolving 30 grains of bicarbonate of potash, and 20 of citric acid, in separate tea-cups of water, mixing the solution in a large tumbler, and drinking the whole during the effervescence. This dose may be repeated 3 or 4 times a-day. The carbonic acid of the above medicine enters the circulation, and passing off by the bladder, is useful in retaining, particularly, the triple phosphate in solution, as was first pointed out by Dr. Wollaston. The bowels should be kept regular by medicine and moderate exercise. The febrile affections of children are frequently attended by an apparently formidable deposite of white sand in the urine. A dose of calomel will generally carry off both the fever and the sand. Air, exercise, bark, bitters, mineral tonics, are in like manner often successful in removing the urinary complaints of grown up persons.

In considering the red gravel, it is necessary to distinguish between these cases in which the sand is actually voided, and those in which it is deposited, after some hours, from originally limpid urine. In the first, the sabulous appearance is an alarming indication of a tendency to form calculi; in the second, it is often merely a fleeting symptom of indigestion. Should it frequently recur, however, it is not to be disregarded.

Bicarbonate of potash or soda is the proper remedy for the red sand, or lithic acid deposite. The alkali may often be beneficially combined with opium. Ammonia, or its crystallised carbonate, may be resorted to with advantage, where symptoms of indigestion are brought on by the other alkalis; and particularly in red gravel connected with gout, in which the joints and kidneys are affected by turns. Where potash and soda have been so long employed as to disagree with the stomach, to create nausea, flatulency, a sense of weight, pain, and other symptoms of indigestion, magnesia may be prescribed with the best effects. The tendency which it has to accumulate in dangerous quantities in the intestines, and to form a white sediment in urine, calls on the practitioner to look minutely after its administration. It should be occasionally alternated with other laxative medicines. Magnesia dissolved in carbonic acid, as Mr. Scheweppe used to prepare it many years ago, by the direction of Mr. Brande, is an elegant form of exhibiting this remedy.

Care must be had not to push the alkaline medicines too far, lest they give rise to the deposition of earthy phosphates in the urine.

Cases occur in which the sabulous deposite consists of a mixture of lithic acid with the phosphates. The sediment of urine in inflammatory disorders is sometimes of this nature; and of those persons who habitually indulge in excess of wine; as also of those who, labouring under hepatic affections, secrete much albumen in their urine. Purges, tonics, and nitric acid, which is the solvent of both the above sabulous matters, are the appropriate remedies. The best diet for patients labouring under the lithic deposite, is a vegetable. Dr. Wollaston's fine observation, that the excrement of birds fed solely upon animal matter, is in a great measure lithic acid, and the curious fact since ascertained, that the excrement of the boa constrictor, fed also entirely on animals, is pure lithic acid, concur in giving force to the above dietetic prescription. A week's abstinence from animal food has been known to relieve a fit of lithic acid gravel, where the alkalis were of little avail. But we must not carry the vegetable system so far as to produce flatulency and indigestion.

Such are the principal circumstances connected with the disease of gravel in its incipient or sabulous state. The calculi formed in the kidneys are, as we have said above, either lithic, oxalic, or cystic; and very rarely indeed of the phosphate species. An aqueous regimen, moderate exercise on horseback when not accompanied with much irritation, cold bathing, and mild aperients, along with the appropriate chemical medicines, must be prescribed in kidney cases. These are particularly requisite immediately after acute pain in the region of the ureter, and inflammatory symptoms have led to the belief that a nucleus has descended into the bladder. Purges, diuretics, and diluents, ought to be liberally enjoined. A large quantity of mucus streaked with blood, or of a purulent aspect, and hæmorrhagy, are frequent symptoms of the passage of the stone into the bladder.

When a stone has once lodged in the bladder, and increased there to such a size as no longer to be capable of passing through the urethra, it is generally allowed by all who have candidly considered the subject, and who are qualified by experience to be judges, that the stone can never again be dissolved; and although it is possible that it may become so loosened in its texture as to be voided piecemeal, or gradually to crumble away, the event is so rare as to be barely probable.

By examining collections of calculi we learn, that in by far the greater number of cases, a nucleus of lithic acid is enveloped in a crust of the phosphates. Our endeavours must therefore be directed towards reducing the excess of lithic acid in the urine to its natural standard; or, on the other hand, to lessen the tendency to the deposition of the phosphates. The urine must be submitted to chemical examination, and a suitable course of diet and medicines prescribed. But the chemical remedies must be regulated nicely, so as to hit the happy equilibrium, in which no deposite will be formed. Here is a powerful call on physicians and surgeons to make themselves thoroughly versant in chemical science; for they will otherwise commit the most dangerous blunders in calculous complaints.

"The idea of dissolving a calculus of uric acid in the bladder, by the internal use of the caustic alkalis," says Mr. Brande, "appears too absurd to merit serious refutation." In respect to the phosphates, it seems possible, by keeping up an unusual acidity in the urine, so far to soften a crust of the calculus as to make it crumble down, or admit of being abraded by the sound; but this is the utmost that can be looked for; and the lithic nucleus will still remain. "These considerations," adds Mr. Brande, "independent of more urgent reasons, show the futility of attempting the solution of a stone of the bladder by the injection of acid and alkaline solutions. In respect to the alkalis, if sufficiently strong to act upon the uric crust of the calculus, they would certainly injure the coats of the bladder; they would otherwise become inactive by combination with the acids of the urine, and they would form a dangerous precipitate from the same cause."—"It therefore appears to me, that Fourcroy and others, who have advised the plan of injection, have thought little of all these obstacles to success, and have regarded the bladder as a lifeless receptacle, into which, as into an India rubber bottle, almost any solvent might be injected with impunity."—*Journal of Science*, vol. viii. p. 216.

It does not appear that the peculiarities of water in different districts have any influence upon the production of calculous disorders. Dr. Wollaston's discovery of the analogy between urinary and gouty concretions has led to the trial in gravel of the *vinum colchici*, the specific for gout. By a note to Mr. Brande's dissertation we learn that benefit has been derived from it in a case of red gravel.

Dr. Henry confirms the above precepts in the following decided language. "These cases, and others of the same kind, which I think it unnecessary to mention, tend to discourage all attempts to dissolve a stone supposed to consist of uric acid, after it has attained considerable size in the bladder; all that can be effected under such circumstances by alkaline medicines appears, as Mr. Brande has remarked, to be the precipitating upon it a coating of the earthy phosphates from the urine; a sort of concretion which, as has been observed by various practical writers, increases much more rapidly than that consisting of uric acid only. The same unfavourable inference may be drawn also from the dissections of those persons in whom a stone was supposed to be dissolved by alkaline medicines; for in these instances it has been found either encysted, or placed out of the reach of the sound by an enlargement of the prostate gland.

The urinary calculus of a dog, examined by Dr. Pearson, was found to consist principally of the phosphates of lime and ammonia, with animal matter. Several taken from horses were of a similar composition. One of a rabbit consisted chiefly of carbonate of lime and animal matter, with perhaps a little phosphoric acid. A quantity of sabulous matter, neither crystallized nor concrete, is sometimes found in the bladder of the horse: in one instance there were nearly 45 pounds. These appear to consist of carbonate of lime and animal matter. A calculus of a cat gave Fourcroy three parts of carbonate and one of the phosphate of lime. That of a pig, according to Berthollet, was phosphate of lime.

The renal calculus in man appears to be of the same nature as the urinary. In that of the horse, Fourcroy found three parts of carbonate and one of phosphate of lime. Dr. Pearson, in one instance, carbonate of lime and animal matter; in two others, phosphates of lime and ammonia, with animal matter.

Arthritic calculi, or those formed in the joints of gouty persons, were once supposed to be carbonate of lime, whence they were called chalkstones; afterward it was supposed that they were phosphate of lime; but Dr. Wollaston has shown that they are lithate of soda. The calculi found sometimes in the pineal, prostate, salivary, and bronchial glands, in the pancreas, in the corpora cavernosa penis, and between the muscles, as well as the tartar, as it is called, that incrusts the teeth, appear to be phosphate of lime. Dr. Crompton, however, examined a calculus taken from the lungs of a deceased soldier, which consisted of lime 45, carbonic acid 37, albumen and water 18. It was very hard, irregularly spheroidal, and measured about 6⅛ inches in circumference.

For the biliary calculi, see GALL. Those called *bezoars* have been already noticed under that article.

It has been observed, that the lithic acid, which constitutes the chief part of most human urinary calculi, and abounds in the arthritic, has been found in no phytivorous animal; and hence has been deduced a practical inference, that abstinence from animal food would prevent their formation. But we are inclined to think this conclusion too hasty. The cat is carnivorous; but it appeared above, that the calculus of that animal is equally destitute of lithic acid. If, therefore, we would form any deduction with respect to regimen, we must look for something used by man, exclusively of all other animals; and this is obviously found in fermented liquors, but apparently in nothing else: and this practical inference is sanctioned by the most respectable medical authorities.

The following valuable *criteria* of the different kinds of urinary calculi, have been given by M. Berzelius in his treatise on the use of the blowpipe.

1. We may recognize *calculi* formed of *uric acid*, from their being carbonized and smoking with an animal odour, when heated by themselves on charcoal or platinum-foil. They dwindle away at the blowpipe flame. Towards the end, they burn with an increase of light; and leave a small quantity of white very alkaline ashes.

To distinguish these concretions from other substances, which comport themselves in the above manner, we must try a portion of the calculus by the humid way. Thus a tenth of a grain of this calculus being put on a thin plate of glass or platinum, along with a drop of nitric acid, we must heat it at the flame of the lamp. The uric acid dissolves with effervescence. The matter, when dried with precaution to prevent it from charring, is obtained in a fine red colour. If the calculus contains but little uric acid, the substance sometimes blackens by this process. We must then take a new portion of the concretion, and after having dissolved it in nitric acid, remove it from the heat: the solution, when nearly dry, is to be allowed to cool and become dry. We then expose it, sticking to its support, to the warm vapour of caustic ammonia. (From water of ammonia heated in a tea-spoon). This ammoniacal vapour develops a beautiful red colour in it. We may also moisten the dried matter with a little weak water of ammonia.

If the concretions are a mixture of uric acid, and earthy phosphate, they carbonize and consume like the above, but their residuum is more bulky; it is not alkaline, nor soluble in water. They exhibit, with nitric acid and ammonia, the fine red colour of uric acid. Their ashes contain phosphate of lime, or of lime and magnesia.

2. *The calculi of urate of soda* are hardly met with except in the concretions round the articulations of gouty patients. When heated alone upon charcoal, they blacken, exhaling an empyreumatic animal odour; they are with difficulty reduced into ashes, which are strongly alkaline, and are capable of vitrifying silica. When there are earthy salts (phosphates) in these concretions, they afford a whitish or opaque grey glass.

3. *The calculi of urate of ammonia* comport themselves at the blowpipe like those of uric acid. A drop of caustic potash makes them exhale, at a moderate heat, much ammonia. We must not confound this odour with the slight ammoniaco-lixivial smell, which pet-

ich disengages from the greater part of animal substances. Urate of soda is likewise found in these calculi.

4. *Calculi of phosphate of lime.* They blacken, with the exhalation of an empyreumatic animal odour, without melting of themselves at the blowpipe, but whiten into an evident calcareous phosphate. With soda they swell up without vitrifying. Dissolved in boracic acid, and fused along with a little iron, they yield a bead of phosphuret of iron.

5. *Calculi of ammoniaco-magnesian phosphate*, heated alone on a plate of platinum, exhale the empyreumatic animal odour, at the same time blackening, swelling up, and becoming finally greyish-white. A kind of greyish-white enamel is in this manner obtained. With borax they melt into a glass, which is transparent, or which becomes of a milky-white on cooling. Soda in small quantity causes them to fuse into a frothy white slag; a larger quantity of soda makes them infusible. They yield, with iron and boracic acid, a bead of phosphuret of iron: with nitrate of cobalt, a glass of a deep red or brown. If salts of lime exist in these concretions, the mixture of them is less fusible.

6. *Calculi of oxalate of lime*, exposed to the blowpipe, exhale at first the urinous smell; they become first of a dull colour at the flame, and afterwards their colour brightens. What remains after a moderate ignition, effervesces with nitric acid. After a smart jet of the flame, there remains quicklime on the charcoal, which reacts like an alkali on the colour of litmus, wild mallow flower, or cabbage, and slakes with water. But this does not happen when the residuum consists of calcareous phosphate.

7. *The siliceous calculus*, heated alone, leaves sub-coriaceous or infusible ashes. Treated with a little soda, these dissolve with effervescence, but slowly, leaving a bead of glass of a grey colour, or of little transparency.

8. Lastly, *the cystic oxide calculi* afford nearly the same results as uric acid at the blowpipe. They readily take fire, burning with a bluish-green flame, without melting, with the disengagement of a lively and very peculiar acid odour, which has some affinity to that of cyanogen. Their ashes, which are not alkaline, redissolve by a jet of the flame, into a greyish-white mass. They do not yield a red colour in their treatment with nitric acid, like the uric acid concretions.

CALICO PRINTING; the art of dyeing cloth (chiefly cotton and linen) topically; that is, impressing figures, in one or more colours, on certain parts of the cloth, while the rest of the surface is left in its original state. See DYEING.

CALOMEL. Chloride of mercury; frequently called mild muriate of mercury; and sometimes, but less properly, submuriate of mercury. See MERCURY.

ON CALORIC.

CALORIC. The agent to which the phenomena of heat and combustion are ascribed. This is hypothetically regarded as a fluid, of inappreciable tenuity, whose particles are endowed with indefinite idio-repulsive powers, and which, by their distribution in various proportions among the particles of ponderable matter, modify cohesive attraction, giving birth to the three general forms of gaseous, liquid, and solid.

Many eminent philosophers, however, have doubted the separate entity of a calorific matter, and have adduced evidence to show that the phenomena might be rather referred to a vibratory or intestine motion of the particles of common matter. The most distinguished advocate of this opinion in modern times is Sir H. Davy, the usual justness and profundity of whose views entitle them to deference. The following sketch of his ideas on this intricate subject, though it graduates perhaps into the poetry of science, cannot fail to increase our admiration of his genius, and to inculcate moderation on the partisans of the opposite doctrine.

"Calorific repulsion has been accounted for, by supposing a subtile fluid capable of combining with bodies, and of separating their parts from each other, which has been named the *matter of heat* or *caloric*.

"Many of the phenomena admit of a happy explanation on this idea, such as the cold produced during the conversion of solids into fluids or gases, and the increase of temperature connected with the condensation of gases and fluids." In the former case we say the matter of heat is absorbed or combined, in the latter it is extruded or disengaged from combination. "But there are other facts which are not so easily reconciled to the opinion. Such are the production of heat by friction and percussion; and some of the chemical changes which have been just referred to." These are, the violent heat produced in the explosion of gunpowder, where a large quantity of aeriform matter is disengaged; and the fire which appears in the decomposition of the euchlorine gas, or protoxide of chlorine, though the resulting gases occupy a greater volume.

"When the temperature of bodies is raised by friction, there seems to be no diminution of their capacities, using the word in its common sense; and in many chemical changes, connected with an increase of temperature, there appears to be likewise an increase of capacity. A piece of iron made red-hot by hammering, cannot be strongly heated a second time by the same means, unless it has been previously introduced into a fire. This fact has been explained by supposing that the fluid of heat has been pressed out of it, by the percussion, which is recovered in the fire; but this is a very rude mechanical idea: the arrangements of its parts are altered by hammering in this way, and it is rendered brittle. By a moderate degree of friction, as would appear from Rumford's experiments, the same piece of metal may be kept hot for any length of time; so that if heat be pressed out, the quantity must be inexhaustible. When any body is cooled, it occupies a smaller volume than before; it is evident therefore that its parts must have approached to each other: when the body is expanded by heat, it is equally evident that its parts must have separated from each other. The immediate cause of the phenomena of heat, then, is motion, and the laws of its communication are precisely the same as the laws of the communication of motion." "Since all matter may be made to fill a smaller volume by cooling, it is evident that the particles of matter must have space between them; and since every body can communicate the power of expansion to a body of a lower temperature, that is, can give an expansive motion to its particles, it is a probable inference that its own particles are possessed of motion; but as there is no change in the position of its parts as long as its temperature is uniform, the motion, if it exist, must be a vibratory or undulatory motion, or a motion of the particles round their axes, or a motion of particles round each other.

"It seems possible to account for all the phenomena of heat, if it be supposed that in solids the particles are in a constant state of vibratory motion, the particles of the hottest bodies moving with the greatest velocity, and through the greatest space; that in liquids and elastic fluids, besides the vibratory motion, which must be conceived greatest in the last, the particles have a motion round their own axes, with different velocities, the particles of elastic fluids moving with the greatest quickness; and that in ethereal substances," the particles move round their own axes, and separate from each other, penetrating in right lines through space. Temperature may be conceived to depend upon the velocities of the vibrations; increase of capacity, on the motion being performed in greater space; and the diminution of temperature, during the conversion of solids into fluids or gases, may be explained on the idea of the loss of vibratory motion, in consequence of the revolution of particles round their axes, at the moment when the body becomes liquid or aeriform; or from the loss of rapidity of vibration, in consequence of the motion of the particles through greater space.

"If a specific fluid of heat be admitted, it must be supposed liable to most of the affections which the particles of common matter are assumed to possess, to account for the phenomena; such as losing its motion when combining with bodies, producing motion when transmitted from one body to another, and gaining projectile motion when passing into free space; so that many hypotheses must be adopted to account for its agency, which renders this view of the subject less simple than the other. Very delicate experiments have been made, which show that bodies, when heated, do not increase in weight. This, as far as it goes, is an evidence against a subtile elastic fluid producing the calorific expansion; but it cannot be considered as decisive, on account of the imperfection of our instruments. A cubical inch of inflammable air requires a good balance to ascertain that it has any sensible weight, and a substance bearing the same relation to this, that this bears to platinum, could not perhaps be weighed by any method in our possession."

It has been supposed, on the other hand, that the observations of Sir Wm. Herschel on the calorific rays which accompany those of light in the solar beam, afford decisive evidence of the materiality of caloric, or at least place the proof of its existence and that of light on the same foundation. That celebrated astronomer discovered, that when similar thermometers were placed in the different parts of the solar beam, decomposed by the prism into the primitive colours, they indicated different temperatures. He estimates the power of heating in the red rays, to be to that of the green rays, as 55 to 26, and to that of the violet rays as 55 to 16. And in a space beyond the red rays, where there is no visible light, the increase of temperature is greatest of all. Thus, a thermometer in the full red ray rose 7° Fahr. in ten minutes; beyond the confines of the coloured beam entirely, it rose in an equal time 9°.

These experiments were repeated by Sir H. Englefield with similar results. M. Berard, however, came to a somewhat different conclusion. To render his experiments more certain, and their effects more sensible, this ingenious philosopher availed himself of the *heliostat*, an instrument by which the sunbeam can be steadily directed to one spot during the whole of its diurnal period. He decomposed by a prism the sunbeam, reflected from the mirror of the heliostat, and placed a sensible thermometer in each of the seven coloured rays. The calorific faculty was found to increase progressively from the violet to the red portion of the spectrum, in which the *maximum* heat existed, and *not* beyond it, in the unilluminated space. The greatest rise in the thermometer took place while its bulb was still entirely covered by the last red rays; and it was observed progressively to sink as the bulb entered into the dark. Finally, on placing the bulb quite out of the visible spectrum, where Herschel fixed the maximum of heat, the elevation of its temperature above the ambient air was found, by M. Berard, to be only one-fifth of what it was in the extreme red ray. He afterwards made similar experiments on the double spectrum produced by *Iceland* crystal, and also on polarized light, and he found in both cases that the calorific principle accompanied the luminous molecules; and that in the positions where light ceased to be reflected, heat also disappeared.

Newton has shown, that the different refrangibility of the rays of light may be explained by supposing them composed of particles differing in size, the largest being at the red, and the smallest at the violet extremity of the spectrum. The same great man has put the query, Whether light and common matter are not convertible into each other? and adopting the idea, that the phenomena of sensible heat depend upon vibrations of the particles of bodies, supposes that a certain intensity of vibrations may send off particles into free space; and that particles in rapid motion in right lines, in losing their own motion, may communicate a vibratory motion to the particles of terrestrial bodies. In this way we can readily conceive how the red rays should impinge most forcibly, and therefore excite the greatest degree of heat.

Enough has now been said to show how little room there is to pronounce dogmatic decisions on the abstract nature of heat. If the essence of the cause be still involved in mystery, many of its properties and effects have been ascertained, and skilfully applied to the cultivation of science and the uses of life.

We shall consider them in the following order:

1. Of the measure of temperature.
2. Of the distribution of heat.
3. Of the general habitudes of heat with the different forms of matter.

It will be convenient to make use of the popular language, and to speak of heat as existing in bodies in greater or smaller quantities, without meaning thereby to decide on the question of its nature.

1. Of the measure of temperature.

If a rod or ring of metal of considerable size, which is fitted to an oblong or circular guage in its ordinary state, be moderately heated, it will be found, on applying it to the cool guage, to have enlarged its dimensions. It is thus that coachmakers enlarge their strong iron rims, so as to make them embrace and firmly bind, by their retraction when cooled, the wooden frame work of their wheels.

Ample experience has proved, that bodies, by being progressively heated, progressively increase in bulk. On this principle are constructed the various instruments for measuring temperature. If the body selected for indicating, by its increase of bulk, the increase of heat, suffered equal expansions by equal increments of the calorific power, then the instrument would be perfect, and we should have a just thermometer, or pyrometer. But it is very doubtful whether any substance, solid or liquid, preserves this equable relation between its increase of volume and increase of heat. The following quotation from a paper which the Royal Society did me the honour to publish in their Transactions for 1818, conveys my notions on this subject:

"I think it indeed highly probable, that every species of matter, both solid and liquid, follows an increasing rate in its enlargement by caloric. Each portion that enters into a body must weaken the antagonist force, cohesion, and must therefore render more efficacious the operation of the next portion that is introduced. Let 1000 represent the cohesive attraction at the commencement, then, after receiving one increment of caloric, it will become $1000 - 1 = 999$. Since the next unit of that divellent agent will have to combat only this diminished cohesive force, it will produce an effect greater than the first, in the proportion of 1000 to 999, and so on in continued progression. That the increasing ratio is, however, greatly less than Mr. Dalton maintains, may, I think, be clearly demonstrated." P. 34.

The chief object of the second chapter of that memoir, is the measure of temperature. The experiments, on which the reasoning of that part is founded, were made in the years 1812 and 1813, in the presence of many philosophical friends and pupils. By means of two admirable micrometer microscopes of Mr. Troughton's construction, attached to a peculiar pyrometer, I found that between the temperatures of melting ice, and the 540th degree Fahr., the apparent elongations of rods of pure copper and iron corresponded *pari passu* with the indications of two mercurial thermometers of singular nicety, made by Mr. Crighton, of Glasgow, compared with a very fine one of Mr. Troughton's. I consider the above results, and others contained in that same paper, as decisive against Mr. Dalton's hypothetical graduation of thermometers. They were obtained and detailed in public lectures many years before the elaborate researches of MM. Petit and Dulong on the same subject appeared; and indeed the paper itself passed through Dr. Thomson's hands to London, many months before the excellent dissertation of the French philosophers was published.

The researches of MM. Dulong and Petit are contained in the 7th volume of the Annales de Chimie et de Physique. They commence with some historical details, in which they observe, "that Mr. Dalton, considering this question from a point of view much more elevated, has endeavoured to establish general laws applicable to the measurement of all temperatures. These laws, it must be acknowledged, form an imposing whole by their regularity and simplicity. Unfortunately, this skilful philosopher proceeded with too much rapidity to generalize his very ingenious notions, but which depended on uncertain *data*. The consequence is, that there is scarcely one of his assertions but what is contradicted by the result of the researches which we are now going to make known." M. Gay Lussac had previously shown, that between the limits of freezing and boiling water, a mercurial and an air thermometer did not present any sensible discordance. The following table of MM. Dulong and Petit gives the results from nearly the freezing to the boiling point of mercury.

TABLE of Comparison of the Mercurial and Air Thermometer.

Temperature indicated by the mercurial.		Corresponding vols. of the same mass of air.	Temperature indicated by an air ther- corrected for the dilatation of glass.	
Centigr.	Fahr.		Centigr.	Fahr.
−36°	−32.8°	0.8650	−36.00°	−32.8°
0	+32	1.0000	.00	+32.0
100	212	1.3750	100.00	212.0
150	302	1.5576	148.70	299.66
200	392	1.7389	197.05	386.69
250	482	1.9189	245.05	475.09
300	572	2.0976	292.70	558.86
Boiling, 360	680	2.3125	350.00	662.00

The well known uniformity in the principal physical properties of all the gases, and particularly the perfect identity in the laws of their dilatation, render it very probable, that in this class of bodies the disturbing causes, to which I have adverted in my paper, have not the same influence as in solids and liquids; and that consequently the changes in volume produced by the action of heat upon air and gases, are more immediately dependent upon the force which produces them. It is therefore very probable, that the greatest number of the phenomena relating to heat will present themselves under a more simple form, if we measure the temperatures by an air thermometer.

I coincide with these remarks of the French chemists, and think they were justified by such considerations to employ the scale of an air thermometer in their subsequent researches, which form the second part of their memoir on the laws of the communication of heat.

The boiling point of mercury, according to MM. Dulong and Petit, measured by a true thermometer, is 662 of Fahr. degrees. Now by Mr. Crighton's thermometer the boiling point is 656°, a difference of only 6° in that prodigious range. Hence we see, as I pointed out in my paper, that there is a compensation produced between the unequable expansions of mercury and glass, and the lessening mass of mercury remaining in the bulb as the temperatures rise, whereby his thermometer becomes a true measurer of the increments of sensible caloric. From all the experiments which have been made with care, we are safe in assuming the apparent expansion of mercury in glass to be 1-63d part of its volume on an average for every 180° Fahr. between 32° and 662°, or through an interval of 7 times 90 degrees. Hence the apparent expansion in glass for the whole is, $\frac{7}{126} = \frac{1}{18} = \frac{35}{630} = 35°$ Fahr.

Were the whole body of the thermometer, stem and bulb, immersed in boiling mercury, it would therefore indicate 35° more than it does when the bulb alone is immersed, or it would mark nearly 691° by Crighton. But the abstraction made of these 35°, in consequence of the bulb alone being immersed in the heated liquids, brings back the common mercurial scale, when well executed, nearly to the absolute and just scale of an air thermometer, corrected for the expansions of the containing glass.

The *real* temperature of boiling mercury by Dulong and Petit is 662° F.; the *apparent* temperature, measured by mercury in glass, *both* heated to the boiling point of the former, is 680°. But the latter is a false indication, and Mr. Crighton's compensated number 656° is very near the truth. We may therefore consider a well made mercurial thermometer as a sufficiently just measurer of temperature. For its construction and graduation, see THERMOMETER.

2. Of the distribution of heat.

This head naturally divides into two parts; first, the modes of distribution, or the laws of cooling, and the communication of heat among aeriform, liquid, and solid substances; and, secondly, the specific heats of different bodies at the same and at different temperatures.

The first views relative to the laws of the communication of heat are to be found in the *Opuscula* of Newton. This great philosopher assumes *à priori*, that a heated body exposed to a constant cooling cause, such as the uniform action of a current of air, ought to lose at each instant a quantity of heat proportional to the excess of its temperature above that of the ambient air; and that consequently its losses of heat in equal and successive portions of time; ought to form a decreasing geometrical progression. Though Martin, in his Essays on Heat, pointed out long ago the inaccuracy of the preceding law, which indeed could not fail to strike any person, as it struck me forcibly the moment that I watched the progressive cooling of a sphere of oil which had been heated to the 500th degree, yet the proposition has been passed from one systematist to another without contradiction.

Erxleben proved, by very accurate observations, that the deviation of the supposed law increases more and more as we consider greater differences of temperatures; and concludes, that we should fall into very great errors if we extended the law much beyond the temperature at which it has been verified. Yet Mr. Leslie since, in his ingenious researches on heat, has made this law the basis of several determinations, which from that very cause are regarded as inaccurate by Dulong and Petit. These gentlemen have investigated the true law in an able manner.

When a body cools *in vacuo*, its heat is entirely dissipated by radiation. When it is placed in air, or in any other fluid, its cooling becomes more rapid, the heat carried off by the fluid being in that case added to that which is dissipated by radiation. It is natural therefore to distinguish these two effects; and as they are subject in all probability to different laws, they ought to be separately studied.

MM. Dulong and Petit employed in this research mercurial thermometers, whose bulbs were from 0.8 of an inch to 2.6; the latter containing about three lbs. of mercury. They found by preliminary trials, that the *ratio* of cooling was not affected by the size of the bulb, and that it held also in comparisons of mercury, with water, with absolute alcohol, and with sulphuric acid, through a range of temperature from 60 to 30 of the centigrade scale; so that the ratio of the velocity of cooling between 60 and 50, and 40 and 30, was sensibly the same. On cooling water in a tin plate, and in a glass sphere, they found the law of cooling to be more rapid in the former, at temperatures under the boiling point; but by a very remarkable casualty, the contrary effect takes place in bodies heated to high temperatures, when the law of cooling in tin plates becomes least rapid. Hence, generally, that which cools by a most rapid law at the lower part of the scale, becomes the least rapid at high temperatures.

"Mr. Leslie obtained such inaccurate results respecting this question, because he did not make experiments on the cooling of bodies raised to high temperatures," say MM. Dulong and Petit, who terminate their preliminary researches by experiments on the cooling of water in three tin-plate vessels of the same capacity, the first of which was a sphere, the second and third cylinders; from which we learn that the law of cooling is not affected by the difference of shape.

The researches on cooling in a vacuum were made with an exhausted balloon; and a compensation was calculated for the minute quantity of residuary gas. The following series was obtained when the balloon was surrounded with ice. The degrees are centigrade.

Excess of the therm. above the balloon.	Corresponding velocities of cooling.
240°	10.69
220	8.81
200	7.40
180	6.10
160	4.89
140	3.88
120	3.02
100	2.30
80	1.74

The first column contains the excesses of temperature above the walls of the balloon; that is to say, the temperatures themselves, since the balloon was at 0°. The second column contains the corresponding velocities of cooling, calculated and corrected. These velocities are the numbers of degrees that the thermometer would sink in a minute. The first series shows clearly the inaccuracy of the geometrical law of Richmann; for according to that law, the velocity of cooling at 200° should be double of that at 100°; whereas we find it as 7.4 to 2.3, or more than triple; and in like manner, when we compare the loss of heat at 240° and at 80°, we find the first about 6 times greater than the last; while, according to the law of Richmann, it ought to be merely triple. From the above and some analogous experiments, the following law has been deduced: *When a body cools* in vacuo, *surrounded by a medium whose temperature is constant, the velocity of cooling for excess of temperature in arithmetical progression, increases as the terms of a geometrical progression, diminished by a certain quantity.* Or, expressed in algebraic language, the following equation contains the law of cooling *in vacuo*: $V = m.a^{\theta}(a^{t} - 1)$.

θ is the temperature of the substance surrounding the vacuum; and t that of the heated body above the former. The ratio a of this progression is easily found for the thermometer, whose cooling is recorded above; for when θ augments by 20°, t remaining the same, the velocity of cooling is then multiplied 1.165, which number is the mean of all the ratios experimentally determined. We have then

$$a = \sqrt[20]{1.165} = 1.0077.$$

It only remains, in order to verify the accuracy of this law, to compare it with the different series, contained in the table inserted above. In that case, in which the surrounding medium was 0°, it is necessary to make $m = 2.037$, for $m = \frac{n}{\log.\, a}$, and n is an intermediate number; we have then $V = 2.037\ (a^{t} - 1)$.

Excesses of temp. or value of *t*.	Values of V observed.	Values of V calculated.
240°	10.69	10.68
220	8.81	8.89
200	7.40	7.34
180	6.10	6.03
160	4.89	4.87
140	3.88	3.89
120	3.02	3.05
100	2.30	2.33
80	1.74	1.72

The laws of cooling *in vacuo* being known, nothing is more simple than to separate from the total cooling of a body surrounded with air, or with any other gas, the portion of the effect due to the contact of the fluid. For this, it is obviously sufficient to subtract from the real velocities of cooling, those velocities which would take place if the body *cæteris paribus* were placed *in vacuo*. This subtraction may be easily accomplished now that we have a formula, which represents this velocity with great precision, and for all possible cases.

From numerous experimental comparisons the following law was deduced: *The velocity of cooling of a body, owing to the sole contact of a gas, depends for the same excess of temperature, on the density and temperature of the fluid; but this dependence is such, that the velocity of cooling remains the same, if the density and the temperature of the gas change in such a way that the elasticity remains constant.*

If we call P the cooling power of air under the pressure p, this power will become P (1.366) under a pressure $2p$; $P\,(1.366)^{2}$ under a pressure $4\,p$; and under a pressure $p\,2^{n}$, it will be $P\,(1.366)^{n}$. Hence $\frac{P'}{P} = \left(\frac{p'}{p}\right)^{0.45}$. We shall find in the same way for hydrogen, $\frac{P'}{P} = \left(\frac{p'}{p}\right)^{0.38}$.

For carbonic acid, the exponent will be 0.517, and for olefiant gas 0.501, while for air, as we see, it is 0.45. These last three numbers differing little from 0.5 or $\frac{1}{2}$, we may say that in the aeriform bodies to which they belong, the cooling power is nearly as the square root of the elasticity. "If we compare the law which we have thus announced," say MM. Dulong and Petit, "with the approximations of Leslie and Dalton, we shall be able to judge of the errors into which they have been led by the inaccurate suppositions which serve as the basis of all their calculations, and by the little precision attainable by the methods which they have followed." But for these discussions, we must refer to the memoir itself.

The influence of the nature of the surface of bodies in the distribution of heat, was first accurately examined by Mr. Leslie. This branch of the subject is usually called the radiation of caloric. To measure the amount of this influence with precision, he contrived a peculiar instrument, called a differential thermometer. It consists of a glass tube, bent into the form of the letter U, terminated at each end with a bulb. The bore is about the size of that of large thermometers, and the bulbs have a diameter of $\frac{1}{4}$ of an inch and upwards. Before hermetically closing the instrument, a small portion of sulphuric acid tinged with carmine is introduced. The adjustment of this liquid, so as to make it stand at the top of one of the stems, immediately below the bulb, requires dexterity in the operator. To this stem a scale divided into 100 parts is attached, and the instrument is then fixed upright by a little cement on a wooden sole. If the finger, or any body warmer than the ambient air, be applied to one of these bulbs, the air within will be heated, and will of course expand, and issuing in part from the bulb, depress before it the tinged liquor. The amount of this depression observed upon the scale, will denote the difference of temperature of the two balls. But if the instrument be merely carried without touching either ball, from a warmer to a cooler, or from a cooler to a warmer air, or medium of any kind, it will not be affected; because the equality of contraction or expansion in the enclosed air of both bulbs, will maintain the equilibrium of the liquid in the stem. Being thus independent of the fluctuations of the surrounding medium, it is well adapted to measure the calorific emanations of different surfaces, successively converged, by a concave reflector, upon one of its bulbs. Dr. Howard has described, in the 10th number of the Journal of Science, a differential thermometer of his contrivance, which he conceives to possess some advantages. Its form is an imitation of Mr. Leslie's; but it contains merely tinged alcohol, or ether, the air being expelled by ebullition previous to the hermetical closure of the instrument. The vapour of ether, or of spirit *in vacuo*, affords, he finds, a test of superior delicacy to air. He makes the two legs of different lengths; since it is in some cases very convenient to have the one bulb standing quite aloof from the other. In Mr. Leslie's, when they are on the same level, their distance asunder varies from $\frac{1}{4}$ of an inch to 1 or upwards, according to the size of the instrument. The general length of the legs of the syphon is about 5 or 6 inches.

His reflecting mirrors, of about 14 inches diameter, consisted of planished tin-plate, hammered into a parabolical form by the guidance of a curvilinear gauge. A hollow tin vessel, 6 inches cube, was the usual source of calorific emanation in his experiments. He coated one of its sides with lamp-black, another with paper, a third with glass, and a fourth was left bare. Having then filled it with hot water, and set it in the line of the axis, and 4 or 6 feet in front of one of the mirrors, in whose focus the bulb of a differential thermometer stood, he noted the depression of the coloured liquid produced on presenting the different sides of the cube towards the mirror in succession. The following table gives a general view of the results, with these, and other coatings :—

Lamp-black,	100
Water by estimate,	100+
Writing paper,	98
Rosin,	96
Sealing wax,	95
Crown glass,	90
China ink,	88
Ice,	85
Red lead,	80
Plumbago,	75
Isinglass,	75
Tarnished lead,	45
Mercury,	20+
Clean lead,	19
Iron polished,	15
Tin-plate,	12
Gold, Silver, Copper,	12

Similar results were obtained by Leslie and Rumford in a simpler form. Vessels of similar shapes and capacities, but of different materials, were filled with hot liquids, and their rates of refrigeration noted. A blackened tin globe cooled a certain number of degrees in 81 minutes; while a bright one took nearly double the time, or 156 minutes; a naked brass cylinder in 55 minutes cooled ten degrees, while its fellow, cased in linen, was 36½ minutes in cooling the same quantity. If rapid motions be excited in the air, the difference of cooling between bright and dark metallic surfaces becomes less manifest. Mr. Leslie estimates the diminution of effect from a radiating surface to be directly as its distance, so that double the distance gives one-half, and treble one-third of the primitive heating impression on thermometers and other bodies. Some of his experiments do not seem in accordance with this simple law. One would have expected certainly, that, like light, electricity, and other qualities emanating from a centre, its diminution of intensity would have been as the square of the distance; and particularly as Mr. Leslie found the usual analogy of the sine of inclination to hold, in presenting the faces of the cube to the plane of the mirror under different angles of obliquity.

Some practical lessons flow from the preceding results. Since bright metals project heat most feebly, vessels which are intended to retain their heat, as tea and coffee-pots, should be made of bright and polished metals. Steam pipes intended to convey heat to a distant apartment, should be likewise bright in their course, but darkened when they reach their destination.

By coating the bulb of his thermometer with different substances, Mr. Leslie ingeniously discovered the power of different surfaces to absorb heat; and he found this to follow the same order as the radiating or projecting quality. The same film of silver leaf which obstructs the egress of heat from a body to those surrounding it, prevents it from receiving their calorific emanations in return. On this principle we can understand how a metallic mirror, placed before a fire, should scorch substances in its focus, while itself remains cold; and, on the other hand, how a mirror of darkened or even of silvered glass, should become intolerably hot to the touch while it throws little heat before it. From this absorbent faculty it comes that a thin pane of glass intercepts almost the whole heat of a blazing fire, while the light is scarcely diminished across it. By degrees indeed, itself becoming heated, constitutes a new focus of emanation, but still the energy of the fire is greatly interrupted. Hence also we see why the thinnest sheet of bright tin-foil is a perfect fire screen; so impervious indeed to heat, that with a masque coated with it, our face may encounter without inconvenience the blaze of a glass-house furnace.

Since absorption of heat goes hand in hand with radiation in the above table, we perceive that the inverse of absorption, that is reflection, must be possessed in inverse powers by the different substances composing the list. Thus bright metals reflect most heat, and so on upwards in succession.

Mr. Leslie is anxious to prove that elastic fluids, by their pulsatory undulations, are the *media* of the projection or radiation of heat; and that therefore liquids, as well as a perfect vacuum, should obstruct the operation of this faculty. The laws of the cooling of bodies *in vacuo*, experimentally established by MM. Dulong and Petit, are fatal to Mr. Leslie's hypothesis, which indeed was not tenable against the numerous objections which had previously assailed it. The following beautiful experiment of Sir H. Davy seems alone to settle the question. He had an apparatus made, by which platina wire could be heated in any elastic medium or *in vacuo*; and by which the effects of radiation could be distinctly exhibited by two mirrors, the heat being excited by a voltaic battery. In several experiments, in which the same powers were employed to produce the ignition, it was found that the temperature of a thermometer rose nearly three times as much in the focus of radiation, when the air in the receiver was exhausted to $\frac{1}{120}$, as when it was in its natural state of condensation. The cooling power, by contact of the rarefied air, was much less than that of the air in its common state, for the glow of the platina was more intense in the first case than in the last; and this circumstance perhaps renders the experiment not altogether decisive; but the results seem favourable to the idea, that the terrestrial radiation of heat is not dependent upon any motions or affections of the atmosphere. The plane of the two mirrors was placed parallel to the horizon, the ignited body being in the focus of the upper, and the thermometer in that of the under mirror. It is evident that a diminished density of the elastic medium, amounting to $\frac{1}{120}$, should, on Mr. Leslie's views, have occasioned a greatly diminished temperature in the inferior focus, and not a threefold increase, as happened; making every allowance for the diminished intensity of glow resulting from the cooling power of atmospheric air. The experiments with screens of glass, paper, &c. which Mr. Leslie adduced in support of his undulatory hypothesis, have been since confronted with the experiments on screens of Dr. Delaroche, who, by varying them, obtained results incompatible with Mr. Leslie's views, and favourable to those on the intimate connexion between light and heat, with which our account of heat was prefaced. He shows that invisible radiant heat, in some circumstances, passes directly through glass, in a quantity so much greater relative to the whole radiation, as the temperature of the source of heat is more elevated. The following table shows the ratio between the rays passing through clear glass, and the rays acting on the thermometer, when no screen was interposed, at successive temperatures.

Temperature of the hot body in the focus.	Rays transmitted through the glass screen.	Total Rays.
357°	10°	263°
655	10	139
800	10	75
1760	10	34
Argand's lamp without its chimney,	10	29
Ditto, with glass chimney,	10	18

He next shows that the calorific rays which have already passed through a screen of glass, experience, in passing through a second glass screen of a similar nature, a much smaller diminution of their intensity than they did in passing through the first screen; and that the rays emitted by a hot body differ from each other in their faculty to pass through glass: that a thick glass, though as much as, or more permeable to light, than a thin glass of worse quality, allows a much smaller quantity of radiant heat to pass, the difference being so much the less the higher the temperature of the radiating source. This curious fact, that radiating heat becomes more and more capable of penetrating glass, as the temperature increases, till at a certain temperature the rays become luminous, leads to the notion that heat is nothing else than a modification of light, or that the two substances are capable of passing into each other. Dr. Delaroche's last proposition is, that the quantity of heat which a hot body yields in a given time by radiation to a cold body situated at a distance, increases *cæteris paribus* in a greater ratio than the excess of temperature of the first body above the second.

For some additional facts on radiation, see LIGHT, to which subject, indeed, the whole discussion probably belongs.

Even ice at 32°, which appears so cold to the organs of touch, would become a focus of heat if transported into a chamber where the temperature of the air was at 0° F.; and a mass of melting ice placed before the mirror, would affect the bulb of the thermometer, just as the cube of heated water did. A mixture of snow and salt at 0°, would in like manner become a warm body when carried into an atmosphere at —40°. In all this, as well as in our sensations, we see nothing absolute, nothing but mere differences. We are thus led to consider all bodies as projecting heat at every temperature, but with unequal intensities, according to their nature, their surfaces, and their temperature. The constancy or steadiness of the temperature of a body will consist in the equality of the quantities of radiating caloric which it emits and receives in an equal time; and the equality of temperature between several bodies which influence one another by their mutual radiation, will consist in the perfect compensation of the momentary interchanges effected among one and all. Such is the ingenious principle of a moveable equilibrium, proposed by Professor Prevost; a principle whose application, directed with discretion, and combined with the properties peculiar to different surfaces, explains all the phenomena which we observe in the distribution of radiating caloric. Thus, when we put a ball of snow in the focus of one concave mirror, and a thermometer in that of an opposite mirror placed at some distance, we perceive the temperature instantly to fall, as if there were a real radiation of frigorific particles, according to the ancient notion. The true explanation is derived from the abstraction of that return of heat which the thermoscope mirror had previously derived from the one now influenced by the snow, and now participating in its inferior radiating tension. Thus, also, a black body placed in the focus of one mirror, would diminish the light in the focus of the other: and, as Sir H. Davy happily remarks, the eye is, to the rays producing light, *a measure*, similar to that which the thermometer is to rays producing heat.

This interchange of heat is finely exemplified in the relation which subsists between any portion of the sky and the temperature of the subjacent surface of the earth. In the year 1788, Mr. Six of Canterbury mentioned, in a paper transmitted to the Royal Society, that on clear and dewy nights he always found the mercury lower in a thermometer laid upon the ground, in a meadow in his neighbourhood, than it was in a similar thermometer suspended in the air 6 feet above the former; and that upon one night the difference amounted to 5° of Fahrenheit's scale. And Dr. Wells, in autumn 1811, on laying a thermometer upon grass wet with dew, and suspending a second in the air two feet above the surface, found in an hour afterwards, that the former stood 8° lower than the latter. He at first regarded this coldness of the surface to be the *effect* of the evaporation of the moisture, but subsequent observations and experiments convinced him, that the cold was not the effect but the *cause* of deposition of dew. Under a cloudless sky, the earth projects its heat without return, into empty space; but a canopy of cloud is a concave mirror, which restores the equilibrium by counter-radiation. See DEW.

On this principle Dr. Wollaston suggested the construction of a pretty instrument, which Professor Leslie has called an Æthrioscope, whose function it is, to denote the clearness and coolness of the sky. It consists of a polished metallic cup, of an oblong spheroidal shape, very like a silver porter-cup, standing upright, with the bulb of a differential thermometer placed in its axis, and the stem lying parallel to the stalk of the cup. The other ball is gilt, and turned outwards and upwards, so as to rest against the side of the vessel. The best form of the cup is an ellipsoid, whose eccentricity is equal to half the transverse axis, and the focus consequently placed at the third part of the whole height of the cavity; while the diameter of the thermoscope ball should be nearly the third part of the orifice of the cup. A lid of the same thin metal unpolished, is fitted to the mouth of the cup, and removed only when an observation is to be made. The scale attached to the stem of the thermoscope, may extend to 60 or 70 millesimal degrees above the zero, and about 15 degrees below it.

This instrument, exposed to the open air in clear weather, will at all times, both during the day and the night, "indicate an impression of cold shot downward from the higher regions," in the figurative language of Mr. Leslie. Yet the effect varies exceedingly. It is greatest while the sky has the pure azure hue; it diminishes fast as the atmosphere becomes loaded with spreading clouds; and it is almost extinguished when low fogs settle on the surface. The liquid in the stem falls and rises with every passing cloud. Dr. Howard's modification of the thermoscope would answer well here.

The diffusion of heat among the particles of fluids *themselves*, depends upon their specific gravity and specific heat conjunctly, and therefore must vary for each particular substance. The mobility of the particles in a fluid, and their reciprocal independence on one another, permit them to change their places whenever they are expanded or contracted by alternations of temperature; and hence the immediate and inevitable effect of communicating heat to the under stratum of a fluid mass, or of abstracting it from the upper stratum, is to determine a series of intestine movements. The colder particles, by their superior density, descend in a perpetual current, and force upwards those rarefied by the heat. When, however, the upper stratum *primarily* acquires an elevated temperature, it seems to have little power of imparting heat to the subjacent strata of fluid particles. Water may be kept long in ebullition at the surface of a vessel, while the bottom remains ice cold, provided we take measures to prevent the heat passing downwards through the sides of the vessel itself. Count Rumford became so strongly persuaded of the impossibility of communicating heat downwards through fluid particles, that he regarded them as utterly destitute of the faculty of transmitting that power from one to another, and capable of acquiring heat only in individual rotation, and directly from a foreign source. The proposition thus absolutely announced is absurd, for we know that by intermixture, and many other modes, fluid particles impart heat to each other; and experiments have been instituted, which prove the actual descent of heat through fluids by communication from one stratum to another. But unquestionably this communication is amazingly difficult and slow. We are hence led to conceive, that it is an actual contact of particles, which in the solid condition facilitates the transmission of heat so speedily from point to point through their mass. This contact of certain poles in the molecules, is perfectly consistent with void spaces, in which these molecules may slide over each other in every direction; by which movements or condensations heat may be excited. The fluid condition *reverts* or *averts* the touching and cohering poles, whence mobility results. This statement may be viewed either as a representation of facts, or an hypothesis to aid conception.

Since the diffusion of heat through a fluid mass is accomplished almost solely by the intestine currents, whatever obstructs these must obstruct the change of temperature. Hence fluids intermingled with porous matter, such as silk, wool, cotton, downs, fur, hair, starch, mucilage, &c. are more slowly cooled than in their pure and limpid state. Hence appletarts and pottages retain their heat very long, in comparison of the same bulk of water heated to the same degree, and exposed in similar covered vessels to the cool air. Of the conducting power of gaseous bodies, we have already taken a view. I know of no experiments which have satisfactorily determined in numbers the relative conducting power of liquids. Mercury for a liquid possesses a high conducting faculty, due to its density and metallic nature, and small specific heat.

The transmission of heat through solids was made the subject of some pleasing popular experiments by Dr. Ingenhausz. He took a number of metallic rods of the same length and thickness, and having coated one of the ends of them for a few inches with bees' wax, he plunged their other ends into a heated liquid. The heat travelled onwards along the matter of each rod, and soon became manifest by the softening of the wax. The following is the order in which the wax melted; and according to that experiment, therefore, the order of conducting power relative to heat.

1. Silver.
2. Gold.
3. Copper, } nearly equal.
4. Tin, }

Platinum, }
Iron, } much inferior to
Steel, } the others.
Lead, }

In my repetition of the experiment, I found silver by much the best conductor, next copper, then brass, iron, tin, much the same, then cast iron, next zinc, and last of all, lead. Dense stones follow metals in conducting power, then bricks, pottery, and at a long interval, glass. A rod of this singular body may be held in the fingers for a long time, at a distance of an inch from where it is ignited and fused by the blowpipe. It is owing to the inferior conducting power of stone, pottery, glass, and cast iron, that the sudden application of heat so readily cracks them. The part acted on by the caloric expands, while the adjacent parts, retaining their pristine form and volume, do not accommodate themselves to the change; whence a fissure must necessarily ensue. Woods and bones are better conductors than glass; but the progress of heat in them at elevated temperatures, may be aided by the vaporization of their juices. Charcoal and saw-dust rank very low in conducting power. Hence the former is admirably fitted for arresting the dispersion of heat in metal furnaces. If the sides of these be formed of double plates, with an interval between them of an inch filled with pounded charcoal, an intense heat may exist within, while the outside is scarcely affected. Morveau has rated the conducting power of charcoal to that of fine sand, as 2 to 3, a difference much too small. Spongy organic substances, silk, wool, cotton, &c. are still worse conductors than any of the above substances; and the finer the fibres, the less conducting power they possess. The theory of clothing depends on this principle. The heat generated by the animal powers, is accumulated round the body by the imperfect conductors of which clothing is composed.

To discover the exact law of the distribution of heat in solids, let us take a prismatic bar of iron, three feet long, and with a drill form three cavities in one of its sides, at 10, 20, and 30 inches from its end, each cavity capable of receiving a little mercury, and the small bulb of a delicate thermometer. Cut a hole fitting exactly the prismatic bar, in the middle of a sheet of tin-plate, which is then to be fixed to the bar, to screen it and the thermometers from the focus of heat. Immerse the extremity of the bar obliquely into oil or mercury heated to any known degree, and place the thermometers in their cavities surrounded with a little mercury. Or the bar may be kept horizontal, if an inch or two at its end be incurvated, at right angles to its length. Call the thermometers A, B, C. Were there no dissipation of the heat, each thermometer would continue to mount till it attained the temperature of the source of heat. But, in actual experiments, projection and aerial currents modify that result, making the thermometers rise more slowly, and preventing them from ever reaching the temperature of the end of the bar. Their state becomes indeed stationary whenever the excess of temperature, each instant communicated by the preceding section of the bar, merely compensates what they lose by the contact of the succeeding section of the bar, and the other outlets of heat. The three thermometers now indicate three steady temperatures, but in diminishing progression. In forming an equation from the experimental results, M. Laplace has shown, that the difficulties of the calculation can be removed only by admitting, that a determinate point is influenced not only by those points which touch it, but by others at a small distance before and behind it. Then the laws of homogeneity, to which differentials are subject, are re-established, and all the rules of the differential calculus are observed. Now, in order that the calorific influence may thus extend to a distance in the interior of the bar, there must operate through the very substance of the solid elements a true radiation, analogous to that observed in air, but whose sensible influence is bounded to distances incomparably smaller. This result is in no respect improbable. In fact, Newton has taught us, that all bodies, even the most opaque, become transparent when rendered sufficiently thin; and the most exact researches on radiating caloric prove, that it does not emanate solely from the external surface of bodies, but also from material particles situated within this surface, becoming no doubt insensible at a very slight depth, which probably varies in the same body with its temperature.

MM. Biot, Fourier, and Poisson, three of the most eminent mathematicians and philosophers of the age, have distinguished themselves in this abtruse investigation. The following is the formula of M. Biot, when one end of the bar is maintained at a constant temperature, and the other is so remote as to make the influence of the source insensible. Let y represent, in degrees of the thermometer, the temperature of the air by which the bar is surrounded; let the temperature of the focus be $y + Y$; then the integral becomes, $\log. y = \log. Y - \frac{x}{M}\sqrt{\frac{b.}{a.}}$ x is the distance from the hot end of the bar, a and b are two coefficients, supposed constant for the whole length of the bar, which serve to accommodate the formula to every possible case, and which must be assigned in each case, agreeably to two observations. M is the modulus of the ordinary logarithmic tables, or the number 2.302585. M. Biot presents several tables of observations, in which sometimes 8, and sometimes 14 thermometers, were applied all at once to successive points of the bar; and then he computes by the above formula what ought to be the temperature of these successive points, having given the temperature of the source; and *vice versa*, what should be the temperature of the source, from the indications of the thermometers. A perfect accordance is shown to exist between fact and theory. Whence we may regard the view opened up by the latter, as a true representation of the condition of the bar. With regard to the application of this theorem, to discover, for example, the temperature of a furnace, by thrusting the end of a thermoscopic iron bar into it, we must regret its insufficiency. M. Biot himself, after showing its exact coincidence at all temperatures, up to that of melting lead, declares that it ought not to apply at high heats. But I see no difficulty in making a very useful instrument of this kind, by *experiment*, to give very valuable pyrometrical indications. The end of the bar which is to be exposed to the heat, being coated with fire-clay, or sheathed with platinum, should be inserted a few inches into the flame, and drops of oil being put into three successive cavities of the bar, we should measure the temperatures of the oil, when they have become stationary, and note the time elapsed to produce this effect. A pyroscope of this kind could not fail to give useful information to the practical chemist, as well as to manufacturers of glass, pottery, steel, &c.

2. *Of specific heat.*—If we take equal weights, or equal bulks, of a series of substances; for example, a pound or a pint of water, oil, alcohol, mercury, and having heated each, separately in a thin vessel, to the same temperature, say to 80° or 100° Fahr. from an atmospherical temperature of 60°, then in the subsequent cooling of these four bodies to their former state, they will communicate to surrounding media very different quantities of heat. And conversely, the quantity of heat requisite to raise the temperature of equal masses of different bodies an equal number of thermometric degrees, is different, but specific for each body. There is another point of view in which specific heats of bodies may be considered relative to their change of form, from gaseous to liquid, and from liquid to solid. Thus the steam of water at 212°, in becoming a liquid, does not change its thermometric temperature 212°, yet it communicates, by this change, a vast quantity of heat to surrounding bodies; and, in like manner, liquid water at 32°, in becoming the solid called ice, does not change its temperature as measured by a thermometer, yet it imparts much heat to surrounding matter. We therefore divide the study of specific heats into two branches: 1. The specific heats of bodies while they retain the same state; and 2. The specific heats, connected with, or developed by, change of state. The first has been commonly called the capacities of bodies for caloric; the second, the latent heat of bodies. The latter we shall consider after *change of state.*

1. Of the specific heats of bodies, while they experience no change of state.

Three distinct experimental modes have been employed to determine the specific heats of bodies: in the whole of which modes, that of water has been adopted for the standard of comparison or unity. 1. In the *first* mode, a given weight or bulk of the body to be examined, being heated to a certain point, is suddenly mixed with a given weight or bulk of another body, at a different temperature; and the resulting temperature of the mixture shows the relation between their specific heats. Hence, if the second body be water, or any other substance whose relation to water is ascertained, the relative heat of the first to that of water will be known. It is an essential precaution in using this mode, to avoid all such chemical action as happens in mixing water with alcohol or acids. Let us take oil for an example. If a pound of it, at 90° Fahr. be mixed with a pound of water at 60°, the resulting temperature will not be the mean 75°, but only 70°. And conversely, if we mix a pound of water heated to 90°, with a pound of oil at 60°, the temperature of the mixture will be 80°. We see here, that the water in the first case acquired 10°, while the oil lost 20°; and in the second case, that the water lost 10°, while the oil gained 20°. Hence we say, that the specific heat of water is double to that of oil, or that the same quantity or intensity of heat which will change the temperature of oil 20°, will change that of water only 10°; and therefore, if the specific heat, or capacity for heat, of water be called 1.000, that of oil will be 0.500. When the experiment has been, from particular circumstances, made with unequal weights, the obvious arithmetical reduction, for the difference, must be made. This is the original method of Black, Irvine, and Crawford.

The *second* mode is in some respects a modification of the first. The heated mass of the matter to be investigated, is so surrounded by a large quantity of the standard substance at an inferior temperature, that the whole heat evolved by the first, in cooling, is received by the second. We may refer to this mode, 1*st*, Wilcke's practice of suspending a lump of heated metal in the centre of a mass of cold water contained in a tin vessel: 2*d*, The plan of Lavoisier and Laplace, in which a heated mass of matter was placed by means of their elegant CALORIMETER, in the centre of a shell of ice; and the specific heat was inferred from the quantity of ice that was liquefied: And 3*d*, The method of Berard and Delaroche, in which gaseous matter, heated to a known temperature, was made to traverse, slowly and uniformly, the convolutions of a spiral pipe, fixed in a cylinder of cool water, till this water rose to a stationary temperature; when, "reckoning from this point, the excess of the temperature of the cylinder above that of the ambient air, becomes proportional to the quantity of heat given out by the current of gas that passed through the cylinder." Each gas was definitely heated, by being passed through a straight narrow tube, placed in the axis of a large tube, filled with the steam of boiling water. The specific heats were then compared to water by two methods. The first consists in subjecting the cylinder, which they call the *calorimeter*, to the action of a current of water perfectly regular, and so slow, that it will hardly produce a greater effect than the current of the different gases. The second method consists in determining, by calculation, the real quantity of heat which the calorimeter, come to its stationary temperature, can lose in a given time; for since, after it reaches this point, it does not become hotter, though the source of heat continues to be applied to it, it is evident that it loses as much heat as it receives. MM. Berard and Delaroche employed these two methods in succession. From the singular ingenuity of their apparatus, and precision of their observations, we may regard their determinations as deserving a degree of confidence to which the previous results, on the specific heat of the gases, are not at all entitled. They have completely overturned the hypothetical structures of Black, Lavoisier, and Crawford, on the heat developed in combustion and respiration, while they give great countenance to the profound views of Sir H. Davy. See COMBUSTION, and APPENDIX.

The *third* method of determining the specific heats of bodies, is by raising a given mass to a certain temperature, suspending it in a uniform cool medium, till it descends through a certain number of thermometric degrees, and carefully noting by a watch the *time* elapsed. It is evident, that if the bodies be invested with the same coating, for instance, glass or burnished metals; if they be suspended in the same medium, with the same excess of temperature; and if their interior constitution relative to the conduction of heat be also the same, then their specific heats will be directly as the times of cooling. I have tried this method, and find that it readily gives, in common cases, good approximations. Some of my results were published in the Annals of Phil. for October 1817, on water, sulphuric acid, spermaceti oil, and oil of turpentine. "A thin glass globe, capable of holding 1800 grains of water, was successively filled with this liquid, and with the others; and being in each case heated to the same degree, was suspended, with a delicate thermometer immersed in it, in a large room of uniform temperature. The comparative times of cooling, through an equal range of the thermometric scale, were carefully noted by a watch in each case." The difference of mobility in the liquid particles may be regarded as very trifling, at temperatures from 100° to 200°. At inferior temperatures, under 80° for example, oil of vitriol, as well as spermaceti oil, becoming viscid, would introduce erroneous results.

Another mode has been lately practised with the utmost scientific refinement by MM. Dulong and Petit. Their experiments were made on metals reduced to fine filings, strongly pressed into a cylindrical vessel of silver, very thin, very small, and the axis of which was occupied by the reservoir of the thermometer. This cylinder, containing about 460 grains of the substance, heated about 12° F. above the ambient medium, was suspended in the centre of a vessel blackened interiorly, surrounded with melting ice, and exhausted of air, to prolong the period of refrigeration, which lasted generally 15 minutes. Their results have disclosed a beautiful and unforeseen relation, between the specific heats and primitive combining ratios or atoms of the metals; namely, *that the atoms of all simple bodies have exactly the same capacity for heat.* Hence the specific heat of a simple substance, multiplied into the weight of its atom or prime equivalent, ought to give always the same product.

The law of specific heats being thus established for elementary bodies, it became very important to examine, under the same point of view, the specific heats of compound bodies. Their process applying indifferently to all substances, whatever be their conductibility or state of aggregation, they had it in their power to subject to experiment a great many bodies, whose proportions may be considered as fixed; but when they endeavoured to mount from these determinations to that of the specific heat of each compound atom, by a method analogous to that employed for the simple bodies, they found themselves stopped by the number of equally probable suppositions among which they had to choose. "If the method," say they, "of fixing the weights of the atoms of simple bodies has not yet been subjected to any certain rule, that of the atoms of compound bodies has been, *a fortiori*, deduced from suppositions purely arbitrary." They satisfy themselves by saying, in the mean time, that abstracting every particular supposition, the observations which they have hitherto made tend to establish this remarkable law, that there always exists a very simple ratio between the capacity for heat of the compound atoms, and that of the elementary atoms.

We shall insert here tabular views of the specific heats determined by the recent researches of these French chemists, reserving, for the end of the volume, the usual more extended, but less accurate tables of specific heat. MM. Petit and Dulong justly remark, that "the attempts hitherto made to discover some laws in the specific heats of bodies have been entirely unsuccessful. We shall not be surprised at this, if we attend to the great inaccuracy of some of the measurements; for if we except those of Lavoisier and Laplace (unfortunately very few), and those by Laroche and Berard for elastic fluids, we are forced to admit, that the greatest part of the others are extremely inaccurate, as our own experiments have informed us, and as might indeed be concluded from the great discordance in the results obtained for the same bodies by different experimenters." From this censure we must except the recent results of MM. Clement and Desormes on gases, which I believe may be regarded as entitled to equal confidence with those of Berard and Delaroche.

TABLE I.—*Of the specific Heats of Gases, by* MM. BERARD *and* DELAROCHE.

	Equal volumes.	Equal weights.	Sp. gravity.
Air,	1.0000	1.0000	1.0000
Hydrogen,	0.9033	12.3401	0.0732
Carbonic acid,	1.2583	0.8280	1.5196
Oxygen,	0.9765	0.8848	1.1036
Azote,	1.0000	1.0318	0.9691
Oxide of azote,	1.3503	0.8878	1.5209
Olefiant gas,	1.5530	1.5763	0.9885
Carbonic oxide,	1.0340	1.0805	0.9569

To reduce the above numbers to the standard of water, three different methods were employed; from which the three numbers, 0.2498, 0.2697, and 0.2813, were obtained for atmospheric air. The experimenters have taken 0.2669 as the mean, to which all the above results are referred, as follows:

TABLE II.

Water,	1.0000
Air,	0.2669
Hydrogen gas,	3.2936
Carbonic acid,	0.2210
Oxygen,	0.2361
Azote,	0.2754
Oxide of Azote,	0.2369
Olefiant gas,	0.4207
Carbonic oxide,	0.2884
Aqueous vapour,	0.8470

The following are the results given by MM. Clement and Desormes, for equal volumes at temperatures from 0° to 60° centigrade, or 32° to 140° Fahr.

TABLE III.

	Inches Barom.	Clement & Desormes.	Delaroche & Berard.
Atmospheric air at	39.6	1.215	1.2396
Ditto	29.84	1.000	1.0000
Ditto	14.92	0.693	
Ditto	7.44	0.540	
Ditto	3.74	0.368	
Do. charged with ether,	29.84	1.000	
Azote,	29.84	1.000	1.0000
Oxygen,	29.84	1.000	0.974
Hydrogen,	29.84	0.664	0.9033
Carbonic acid,	29.84	1.500	1.2583

The relative specific heat of air to water is, by MM. Clement and Desormes, 0.250 to 1.000, or exactly one-fourth. The last table, which is extracted from the *Journal de Physique*, gives the specific heat of oxygen by Delaroche and Berard, a little different from their own number, Table I. from the *Annales de Chimie*, vol. 85. The most remarkable result given by MM. Clement and Desormes regards carbonic acid, which being reduced to the standard of weights, gives a specific heat compared to air of about 0.987 to 1.000, while oxygen is only 0.9000. The former tables of Crawford and Dalton give the sp. heat of oxygen 2.65, and of carbonic acid 0.586, compared to air 1.000. And upon these very erroneous numbers, they reared their hypothetical fabric of latent heat, combustion, and animal temperature.

We shall refer to the above table in treating of combustion.

We see from the experiments on air, at different densities, that its specific heat diminishes in a much lower rate than its specific gravity. When air is expanded to a quadruple volume, its specific heat becomes 0.540, and when expanded to eight times the volume, its specific heat is 0.368. The densities in the geometrical progression 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, correspond nearly to the specific heats in the arithmetical series 5, 4, 3, 2. Hence also the specific heat of atmospherical air, and of probably all gases, considered in the ratio of its weight or mass, diminishes as the density increases. On the principle of the increase of specific heat, relative to its mass, has been explained the long observed phenomenon of the intense cold which prevails on the tops of mountains, and generally in the upper regions of the atmosphere; and also that of the prodigious evolution of heat when air is forcibly condensed. According to M. Gay Lussac, a condensation of volume amounting to four-fifths, is sufficient to ignite tinder. If a syringe of glass be used, a vivid flash of light is seen to accompany the condensation.

TABLE IV.—*Of Specific Heats of some Solids, determined by* DULONG *and* PETIT.

	Specific heats, that of water being 100.	Weight of the atoms, oxygen being 1.	Product of these two numbers.
Bismuth,	0·0288	13·300	0·3830
Lead,	0·0293	12·950	0·3794
Gold,	0·0298	12·430	0·3704
Platinum,	0·0314	11·160	0·3740
Tin,	0·0514	7·350	0·3779
Silver,	0·0557	6·750	0·3759
Zinc,	0·0927	4·030	0·3736
Tellurium,	0·0912	4·030	0·3675
Copper,	0·0949	3·957	0·3755
Nickel,	0·1035	3·690	0·3819
Iron,	0·1100	3·392	0·3731
Cobalt,	0·1498	2·460	0·3685
Sulphur,	0·1880	2·011	0·3780

The above products, which express the capacities of the different atoms, approach so near to equality, that the slight differences must be owing to slight errors, either in the measurement of the capacities, or in the chemical analyses, especially if we consider, that, in certain cases, these errors, derived from these two sources, may be on the same side, and consequently be found multiplied in the result. Each atom of these simple bodies seems, therefore, as was formerly stated, to have the same capacity for heat.

An important question now occurs, whether the relative capacities for heat of different solid and liquid bodies be uniform at different temperatures, or whether it vary with the temperature? This question may be perhaps more clearly expressed thus: Whether a body, in cooling a certain thermometric range at a high temperature, gives out the same quantity of heat that it does in cooling through the same range at a lower temperature? No means seem better adapted for solving this problem, than to measure the refrigeration produced, by the same weights of ice, on uniform weights of water, at different temperatures. Mr. Dalton found in this way, that "176.5° expresses the number of degrees of temperature, such as are found between 200° and 212° of the old or common scale, entering into ice of 32° to convert it into water of 32°; 150° of the same scale, between 122° and 130°, suffice for the same effect; and between 45° and 50°, 128° are adequate to the conversion of the same ice into water. These three resulting numbers (128, 150, 176.5) are nearly as 5, 6, 7. Hence it follows, that as much heat is necessary to raise water 5° in the lower part of the old scale, as is required to raise it 7° in the higher, and 6° in the middle."—*See his New System of Chemical Philos.* vol. i. p. 53.

Mr. Dalton, instead of adopting the obvious conclusion that the capacity of water for heat is greater at lower than it is at higher temperatures, and that therefore a smaller number of degrees at the former, should melt as much ice as a greater number at the latter, ascribes the deviation denoted by these numbers, 5, 6, and 7, to the gross errors of the ordinary thermometric graduation, which he considers so excessive, as not only to equal, but greatly to overbalance the *really* increased specific heat or capacity of water; which, viewed in itself, he conceives would have exhibited opposite experimental results. That our *old*, and, according to his notions, *obsolete* thermometric scale, has no such prodigious deviation from truth, is, I believe, now fully admitted by chemical philosophers; and therefore the only legitimate inference from these very experiments of Mr. Dalton, is the *decreasing* capacity of water, with the *increase* of its temperature. It deserves to be remarked, that my experiments on the relative times of cooling a globe of glass, successively filled with water, oil of vitriol, common oil, and oil of turpentine, give exactly the same results as Mr. Dalton had derived from mixtures of two ounces of ice with 60 of water, at different temperatures. This concurrence is the more satisfactory, since, when my paper on the specific heats of the above bodies, published in the Annals of Philosophy for October 1817, was written, I had no recollection of Mr. Dalton's experiments.

TABLE V.—*Of Capacities for Heat.*

Mean capacity between 0° and 100°.		Mean capacity between 0° and 3000°.
Mercury,	0·0330	0·0350
Zinc,	0·0927	0·1015
Antimony,	0·0507	0·0549
Silver,	0·0557	0·0611
Copper,	0·0949	0·1013
Platinum,	0·0355	0·0355
Glass,	0·1770	0·1900

The capacity of iron was determined at the four following intervals:

From 0 to 100°, the capacity is	0·1098
0 to 200	0·1150
0 to 300	0·1218
0 to 350	0·1255

If we estimate the temperatures, as some philosophers have proposed, by the ratios of the quantities of heat which the same body gives out in cooling to a determinate temperature, in order that this calculation be exact it would be necessary that the body in cooling, for example, from 300° to 0°, should give out three times as much heat as in cooling from 100° to 0°. But it will give out more than three times as much, because the capacities are increasing. We should therefore find too high a temperature. We exhibit in the following table the temperatures that would be deduced by employing the different metals contained in the preceding table. We must suppose that they have been all placed in the same liquid bath at 300°, measured by an air thermometer.

Iron,	332·2
Mercury,	318·2
Zinc,	328·5
Antimony,	324·8
Silver,	329·3
Copper,	320·0
Platinum,	317·9
Glass,	322·1

Experiments have been instituted, and theorems constructed, for determining the absolute quantity of heat in bodies, and the point of the total privation of that power, or of absolute cold, on the thermometric scale. The general principle on which most of the inquirers have proceeded is due to the ingenuity of Dr. Irvine. Supposing, for example, the capacity of ice to be to that of water as 8 to 10, at the temperature of 32°, we know that in order to liquefy a certain weight of ice, as much heat is required as would heat the same weight of water to 140° Fahr. Hence, 140° represent two-tenths or one-fifth of the whole heat of fluid water; and therefore the whole heat will be 5 × 140° = 700° below 32°. It is needless to present any algebraic equations on a principle which is probably erroneous, and which has certainly produced in experiment most discordant results. Mr. Dalton has given a general view of them in his section on the zero of temperature.

If we estimate the capacity of ice to that of water as 9 to 10, then the zero will come out . . . . . . 1400°

Gadolin, from the heat evolved in mixing sulphuric acid and water in different proportions, and comparing the capacity of the compound with those of its components, deduced the opposite numbers,	2936 1710 1510 2637 3230 1740

Mr. Dalton from sulphuric acid and water, ... 6400°
Ditto ditto ditto 4150
Ditto ditto ditto 6000

He thinks these to be no nearer approximations to the truth than Gadolin's.

From the heat evolved in slaking lime, compared to the specific heats of the compound, and its constituents, lime and water, Mr. Dalton gives as the zero, ...	4260

From nitric acid and lime, Mr. Dalton finds 11000

From the combustion of hydrogen, 5400

From Lavoisier and Laplace's experiments on slaked lime, . . . 3428

From their experiments on sulphuric acid and water, ... 7262
Ditto ditto ditto 2598
Ditto from nitric acid and lime, + 23837
Dr. Irvine placed it below 30°, = 900
Dr. Crawford ditto ditto, = 1500

The above result of Lavoisier and Laplace on nitric acid and lime, shows the theorem in a very absurd point of view, for it places the zero of cold *above* melting platina. MM. Clement and Desormes have been lately searching after the absolute zero, and are convinced that it is at 266.66° below the zero of the centigrade scale, or − 448° Fahr. This is a more conceivable result. But MM. Dulong and Petit have been led by their investigation to fix the absolute zero at infinity. "This opinion," say they, "rejected by a great many philosophers because it leads to the notion that the quantity of heat in bodies is infinite, supposing their capacity constant, becomes probable, now that we know that the specific heats diminish as the temperatures sink. In fact, the law of this diminution may be such, that the integral of heat, taken to a temperature infinitely low, may notwithstanding have a finite value." They further infer, that the quantity of heat developed at the instant of the combination of bodies has no relation to the capacity of the elements; and that in the greatest number of cases, this loss of heat is not followed by any diminution in the capacity of the compounds formed. This consequence of their researches, if correct, is fatal to the theorem of Irvine, and to all the inferences that have been drawn from it.

3. *Of the general habitudes of heat, with the different forms of matter.*

The effects of heat are either transient and physical, or permanent and chemical, inducing a durable change in the constitution of bodies. The second mode of operation we shall treat of under COMBUSTION. The first falls to be discussed here; and divides itself naturally into the two heads, of changes in the volume of bodies while they retain their form, and changes in the state of bodies.

1st, The successive increments of volume which bodies receive with successive increments of temperature, have been the subjects of innumerable researches. The expansion of fluids is so much greater than that of solids by the same elevation of their temperature, that it becomes an easy task to ascertain within certain limits the augmentation of volume which liquids and gases suffer through a moderate thermometric range. We have only to enclose them in a glass vessel of a proper form, and expose it to heat. But to determine their expansions with final accuracy, and free the results from the errors arising from the unequable expansion of the recipient, is a problem of no small difficulty. It seems, however, after many vain attempts by preceding experimenters, to have been finally solved by MM. Dulong and Petit. The expansion of solids had been previously measured with considerable accuracy by several philosophers, particularly by Smeaton, Roy, Ramsden, and Troughton, in this country, and Lavoisier and Laplace in France. The method devised by General Roy, and executed by him in conjunction with Ramsden, deserves the preference. The metallic or other rod, the subject of experiment, was placed horizontally in a rectangular trough of water, which could be conveniently heated. At any aliquot distance on the rod, two micrometer microscopes were attached at right angles to it, so that each being adjusted at first to two immoveable points, exterior to the heating apparatus, when the rod was elongated by heat, the displacement of the microscopes could be determined to a very minute quantity, to the twenty or thirty thousandth of an inch, by the micrometrical mechanism.

The apparatus of Lavoisier and Laplace was on Smeaton's plan, a series of levers; but differed in this respect, that the last lever gave a vertical motion to a telescope of six feet focal length, whose quantity of displacement was determined by a scale in its field of view from 100 to 200 yards distant. This addition of a micrometrical telescope was ingenious; but the whole mechanism is liable to many objections, from which that of Ramsden was free. Still when managed by such hands and heads as those of Lavoisier and Laplace, we must regard its results with veneration. MM. Dulong and Petit have measured the dilatations of some solids as well as mercury, on plans which merit equal praise for their originality and philosophical precision. They commenced with mercury. Their method with it is founded on this incontestable law of hydrostatics, that when two columns of a liquid communicate by means of a lateral tube, the vertical heights of these two columns are precisely the inverse of their densities. In the axis of two upright copper cylinders, vertical tubes of glass were fixed, joined together at bottom by a horizontal glass tube resting on a levelled iron bar. One of the cylinders was charged with ice, the other with oil, to be warmed at pleasure by a subjacent stove. The rectangular inverted glass syphon was filled nearly to the top with mercury, and the height at which the liquid stood in each leg was determined with nicety by a telescopic micrometer, revolving in a horizontal plane on a vertical rod. The telescope had a spirit level attached to it, and could be moved up or down a very minute quantity by a fine screw. The temperature of the oil, the medium of heat, was measured by both an air and a mercurial thermometer, whose bulbs occupied nearly the whole vertical extent of the cylinder. The elongation of the heated column of mercury could be rigorously known by directing the eye through the micrometer, first to its surface, and next to that in the ice-cold leg. Having by a series of careful trials ascertained the expansions of mercury through different thermometric ranges, they then determined the expansion of glass from the apparent expansions of mercury within it. They filled a thermometer with well boiled mercury, and plunging it into ice, waited till the liquid became stationary, and then cut across the stem at the point where the mercury stood. After weighing it exactly, they immersed it for some time in boiling water. On withdrawing, wiping, and weighing it, they learned the quantity of mercury expelled, which being compared with the whole weight of the mercury in it at the temperature of melting ice, gave the dilatation of volume. This is precisely the plan employed long ago by Mr. Crighton, as well as myself, and which gave the quantity 1-63d, employed in my paper, for the apparent dilatation of mercury in glass.

Their next project was to measure the dilatation of other solids; and this they accomplished with much ingenuity, by enclosing a cylinder of the solid, iron for example, in a glass tube, which was filled up with mercury, after its point had been drawn out to a capillary point. The mercury having been previously boiled in it, to expel all air and moisture, the tube was exposed to different temperatures. By determining the weight of the mercury which was driven out, it was easy to deduce the dilatation of the iron; for the volume driven out obviously represents the sum of the dilatations of the mercury and the metal, diminished by the dilatation of the glass. To make the calculation, it is necessary to know the volumes of these three bodies at the temperature of freezing water; but that of the iron is obtained by dividing its weight by its density at 32°. We deduce in the same manner the volume of the glass from the quantity of mercury which fills it at that temperature. That of the mercury is obviously the difference of the first two. The process just pointed out may be applied likewise to other metals, taking the precaution merely to oxidize their surface in order to hinder amalgamation.

In the years 1812 and 1813 I made many experiments with a micrometrical apparatus of a peculiar construction, for measuring the dilatation of solids. I was particularly perplexed with the rods of zinc, which after innumerable trials I finally found to elongate permanently by being alternately heated and cooled. It would seem that the plates composing this metal, in sliding over each other by the expansive force of heat, present such an adhesive friction as to prevent their entire retraction. It would be desirable to know the limit of this effect, and to see what other metals are subject to the same change. I hope to be able ere long to finish these pyrometrical researches.

I shall now present a copious table of dilatations, newly compiled from the best experiments.

TABLE I.—*Linear Dilatation of Solids by Heat.*

Dimensions which a bar takes at 212°, whose length at 32° is 1.000000.

			Dilatation in Vulgar Fractions.
Glass tube,	Smeaton . . .	1.00083333	
do.	Roy, ...	1·00077615	
do.	Deluc's mean, . .	1·00082800	$\frac{1}{1208}$
do.	Dulong and Petit, .	1·00086130	$\frac{1}{1161}$
do.	Lavoisier and Laplace,	1·00081166	$\frac{1}{1232}$
Plate glass,	do. do.	1.00089089	$\frac{1}{1122}$
do. crown glass,	do. do.	1·00087572	$\frac{1}{1142}$
do. do.	do. do.	1·00089760	$\frac{1}{1090}$
do. do.	do. do.	1·00091751	
do. rod,	Roy, ...	1·00080787	
Deal,	Roy, as glass, . .	....	
Platina,	Borda, . . .	1·00085655	
do.	Dulong and Petit, .	1·00088420	$\frac{1}{1131}$
do.	Troughton, . .	1·00099180	
do. and glass,	Berthoud, . .	1·00110000	
Palladium,	Wollaston, . .	1·00100000	
Antimony,	Smeaton, . .	1.00108300	
Cast iron prism,	Roy, . . .	1.00110940	
Cast iron,	Lavoisier, by Dr. Young,	1·00111111	
Steel,	Troughton, . .	1.00118990	
Steel rod,	Roy, . . .	1·00114470	
Blistered steel,	Phil. Trans. 1795. 428,	1·00112500	
do.	Smeaton, . .	1·00115000	
Steel not tempered,	Lavoisier and Laplace,	1·00107875	$\frac{1}{927}$
do. do. do.	do. do.	1.00107956	$\frac{1}{926}$
do. tempered yellow,	do. do.	1·00136900	
do. do. do.	do. do.	1·00138600	
do. do. do. at a higher heat,	do. do.	1·00123956	$\frac{1}{807}$
Steel,	Troughton, . .	1·00118980	
Hard steel,	Smeaton, . . .	1·00122500	
Annealed steel,	Muschenbroek, . .	1·00122000	
Tempered steel,	do. . .	1·00137000	
Iron,	Borda, . . .	1·00115600	
do.	Smeaton, . . .	1·00125800	
Soft iron, forged,	Lavoisier and Laplace,	1·00122045	
Round iron, wire-drawn,	do. do.	1·00123504	
Iron wire,	Troughton, . .	1·00144010	
Iron,	Dulong and Petit, .	1·00118203	$\frac{1}{846}$
Bismuth,	Smeaton, . .	1·00139200	
Annealed gold,	Muschenbroek, .	1·00146000	
Gold,	Ellicot, by comparison,	1·00150000	
do. procured by parting,	Lavoisier and Laplace,	1·00146606	$\frac{1}{682}$
do. Paris standard, unannealed,	do. do.	1·00155155	$\frac{1}{645}$
do. do. annealed,	do. do.	1·00151361	$\frac{1}{661}$
Copper,	Muschenbroek, . .	1·0019100	
do.	Lavoisier and Laplace,	1·00172244	$\frac{1}{581}$
do.	do. do.	1·00171222	$\frac{1}{584}$
do.	Troughton, . .	1·00191880	
do.	Dulong and Petit, .	1.00171821	$\frac{1}{582}$
Brass,	Borda, . .	1·00178300	
do.	Lavoisier and Laplace,	1·00186671	
do.	do. do.	1·00188971	
Brass scale, supposed from Hamburg,	Roy, . . .	1·00185540	

Dimensions which a bar takes at 212°, whose length at 32° is 1.000000.			Dilatation in Vulgar Fractions.
Cast brass,	Smeaton, . .	1.00187500	
English plate-brass, in rod,	Roy, . . .	1.00189280	
do. do. in a trough form,	do. . .	1.00189490	
Brass,	Troughton, . .	1.00191880	
Brass wire,	Smeaton, . .	1.00193000	
Brass,	Muschenbroek, .	1.00216000	
Copper 8, tin 1,	Smeaton, . .	1.00181700	
Silver,	Herbert, . .	1.00189000	
do.	Ellicot, by comparison,	1.0021000	
do.	Muschenbroek, .	1.00212000	
do. of cupel,	Lavoisier and Laplace,	1.00190974	$\frac{1}{524}$
do. Paris standard,	do. do.	1.00190868	$\frac{1}{524}$
Silver,	Troughton, . .	1.0020826	
Brass 16, tin 1,	Smeaton, . .	1.00190800	
Speculum metal,	do. . . .	1.00193300	
Spelter solder; brass 2, zinc 1,	do. . . .	1.00205800	
Malacca tin,	Lavoisier and Laplace,	1.00193765	$\frac{1}{516}$
Tin from Falmouth,	do. do.	1.00217298	$\frac{1}{462}$
Fine pewter,	Smeaton, . .	1.00228300	
Grain tin,	do. . . .	1.00248300	
Tin,	Muschenbroek, .	1.00284000	
Soft solder; lead 2, tin 1,	Smeaton, . .	1.00250800	
Zinc 8, tin 1, a little hammered,	do. . .	1.00269200	
Lead,	Lavoisier and Laplace,	1.00284836	$\frac{1}{351}$
do.	Smeaton, . .	1.00286700	
Zinc,	do. . .	1.00294200	
Zinc, hammered out ½ inch per foot,	do. . .	1.00301100	
Glass, from 32°, to 212°,	Dulong and Petit, .	1.00086130	$\frac{1}{1161}$
do. from 212°, to 392°,	do. do. .	1.00091827	$\frac{1}{1089}$
do. from 392°, to 572°,	do. do. .	1.000101114	$\frac{1}{987}$

The last two measurements by an air thermometer.

To obtain the expansion in volume, multiply the above decimal quantities by three, or divide the denominators of the vulgar fractions by three; the quotient in either case is the dilatation sought.

We see that a condensed metal, one whose particles have been forcibly approximated by the wire-drawing process, expands more, as might be expected, than metals in a looser state of aggregation. The result for pewter, I conceive, must be inaccurate. Lead ought to communicate to tin, surely, a greater expansive property. Borda's measure of platina is important. It was observed with the *rules* which served for measuring the base of the trigonometrical survey in France. The observations in the table on tempered steel, are, I believe, by that eminent artist, Fortin, though they are included in the table which M. Biot published, under the title of Lavoisier and Laplace.

The amount of the dilatation of metals becomes very useful to determine, in certain cases, the change of dimension to which astronomical instruments are liable. Thus, in measuring a base for the grand operation of the meridian of France, Borda sought to elude the uncertainties arising from expansion of the measuring rods, by combining metallic bars, so that they indicated, of themselves, their variations of temperature and of length. A rule of platina, twelve feet long, was attached by one of its extremities to a rule of copper somewhat shorter, which rested freely on its surface, when placed in a horizontal position. Towards the loose end of the copper rule, there was traced on the platina rule very exact linear divisions, the parts of which were millionths of the total length of this rule. The end of the copper rule carried a vernier, whose coincidences with the platina graduations were observed with a microscope. Now, the dilatations of the platina and copper being unequal for equal changes of temperature, we may conceive that the vernier of the copper rule would incessantly correspond to variable divisions, according as the temperatures varied. Borda made use of these changes to know at every instant the common temperature of these two bars, and the ratio of the absolute dilatations of their two metals. The value of the vernier divisions had been previously ascertained, by plunging the compound bar into water of different temperatures, contained in an oblong wooden trough. It was therefore sufficient to read the indications of this metallic thermometer, in order to learn the true temperature of the bars in the atmosphere; and, of course, the compensation to be made in the *meter* rods or chains, to bring them to the true length at the standard temperature.

An exact acquaintance with the dilatation of metals, is also necessary for regulating the length of the pendulum in astronomical clocks. When the ball or bob of a seconds pendulum is let down $\frac{1}{100}$ of an inch, the clock will go ten seconds slower in 24 hours; and therefore $\frac{1}{1000}$ of an inch will make it lose one second per day. Now, as the effective length of the seconds pendulum is 39·13929 inches, we know from the previous table of expansion, that a change of 30 degrees of temperature by Fahrenheit's scale, will alter its length about $\frac{1}{5000}$ part, which is equivalent to nearly 0·0078, or $\frac{1}{128}$ of an inch, corresponding to about eight seconds of error in the day. The first, the most simple, and most perfect invention for obviating these variations, is due to Graham. The bob of his compensation pendulum consisted of a glass cylinder, about six inches long, holding ten or twelve pounds of mercury. In proportion as the iron or steel rod to which this was suspended, dilated by heat, the mercury also expanded, and raised thereby the centre of oscillation, just as much as the lengthening of the rod had depressed it. M. Biot, with his usual accuracy, has shown, that if the suspending rod were of glass, the length of the cylinder of mercury would require to be 1-10th the total length of the pendulum, namely, about four inches; but the expansion of iron being greater in the ratio, pretty nearly of three to two, we have hence the length of the cylinder in the latter case, equal to about six inches. The late very ingenious Mr. Gavin Lowe prescribed, along with a steel rod, a glass cylinder two inches diameter inside, containing $6\frac{4}{10}$ vertical inches of mercury, weighing ten pounds. From accurate calculation he found, that if such a pendulum should go perfectly true when the thermometer is at 30°, but that at 90° it should go one second slower in 24 hours, it would be remedied by pouring in ten ounces more quicksilver; or, by taking out that quantity, if it went one second faster in 24 hours, when at 90° than at 30° Fahr.; and for 1-10th of a second of deviation in 24 hours, the compensation is the addition or abstraction of one ounce of mercury. See a useful paper on this subject, by Mr. Firminger, in the Philosophical Magazine for August 1819.

The balance wheel of a watch varies, in the time of its oscillations, by its expansions and contractions with variations of temperature. The invention of Arnold furnished a wheel or interrupted ring, composed of concentric laminæ of two metals, which, obviating the above defect by their difference of dilatation, has, under the name of compensation balance, incalculably improved the accuracy of marine chronometers. We shall describe under THERMOMETER, an elegant instrument constructed on similar principles, by the celebrated M. Breguet. See other applications, *infra.*

TABLE II.—*Dilatation of the volume of* LIQUIDS *by being heated from* 32° *to* 212°.

Mercury,	Dalton,	0·020000	$\frac{1}{50}$
do.	Lord Charles Cavendish,	0·018870	$\frac{1}{53}$
do.	Deluc,	0·018000	$\frac{1}{55}$
do.	General Roy,	0·017000	$\frac{1}{59}$
do.	Shuckburgh,	0·01851	$\frac{1}{54}$
do.	Lavoisier and Laplace,	0·01810	$\frac{1}{55.22}$
do.	Haelestroem,	0·0181800	$\frac{1}{55}$
do.	Dulong and Petit,	0·0180180	$\frac{1}{55\cdot50}$
do.	do. from 212°, to 392°,	0·0184331	$\frac{1}{54\ 25}$
do.	do. from 392°, to 572°,	0·0188700	$\frac{1}{53}$
do.	do. in glass, from 32°, to 212°,	0·015432	$\frac{1}{64.8}$
do.	do. do. from 212°, to 392°,	0·015680	$\frac{1}{63\cdot78}$
do.	do. do. from 392°, to 572°,	0·0158280	$\frac{1}{63\cdot18}$
Water, Kirwan, from 39°, its maximum density,		0·04332	$\frac{1}{23\cdot08}$
Muriatic acid, (sp. gr. 1·137),	Dalton,	0·0600	$\frac{1}{17}$
Nitric acid, (sp. gr. 1·40),	do.	0·1100	$\frac{1}{9}$
Sulphuric acid, (sp. gr. 1·85),	do.	0·0600	$\frac{1}{17}$
Alcohol,	do.	0·1100	$\frac{1}{9}$
Water,	do.	0·0460	$\frac{1}{22}$
Water saturated with common salt,	do.	0·0500	$\frac{1}{20}$
Sulphuric ether,	do.	0·0700	$\frac{1}{14}$
Fixed oils,	do.	0·0800	$\frac{1}{12\cdot5}$
Oil of turpentine,	do.	0·0700	$\frac{1}{14}$
The quantities given by Mr. Dalton are probably too great, as is certainly the case with mercury; his experiments being perhaps modified by his hypothetical notions.			
Water saturated with common salt,	Robison,	0·05198	$\frac{1}{19}$

Dr. Young, in his valuable *Catalogue Raisonnée*, Natural Philosophy, vol. ii. p. 391, gives the following table of the expansions of water, constructed from a collation of experiments by Gilpin, Kirwan, and Achard. He says, that the degrees of Fahrenheit's thermometer, reckoning either way from 39° being called f, the expansion of water is nearly expressed by $22f^2$ $(1 — \cdot 002f)$ in 10 millionths; and the diminution of the spec. gravity by $\cdot 0000022f^2 — \cdot 0000000472f^3$. This equation, as well as the table, are very important for the reduction of specific gravities of bodies, taken by weighing them in water.

	Sp. grav.		Dimin. of sp. gr.	Expansion.
30°	0·99980		0·00020	
32	0·99988		0·00012	
34	0·99994		0·00006	
39	1·00000		0·00000	
44	0·99994		0·00006	
48	0·99982		0·00018	
49	0·99978		0·00022	
54	0·99951		0·00049	
59	0·99914		0·00086	
60	0·99906		0·00094	
64	0·99867		0·00133	
69	0·99812		0·00188	
74	0·99749		0·00251	
(77°)	0·99701	Achard		0·00299
79	0·99680	Gilpin	0·00320	0·00321
(82)	0·99612	Kirwan	0·00388	0·00389
90	0·99511	Gilpin	0·00489	0·00491
100	0·99313		0·00687	0·00692
102	0·99246	Kirwan	0·00754	0·00760
122	0·98757		0·01243	0·01258
	0·98872	Deluc	0·01128	
142	0·98199	K.	0·01801	0·01833
162	0·97583		0·02417	0·02481
167	0·97480	Deluc	0·02520	
182	0·96900	K.	0·03100	0·03198
202	0·96145		0·03855	0·04005
212	0·95848		0·04152	0·04333

Deluc introduced into a series of thermometer glasses the following liquids, and noted their comparative indications by expansion at different degrees of heat, measured on Reaumur's thermometer, of which 80° is the boiling point of water, and 0° the melting point of ice.

TABLE of Thermometric Indications by DELUC.

Mercury.			Olive Oil.	Es. Oil of Chamomile.	Oil of Thyme.	Alcohol.	Brine.	Water.
R.	Cent.	Fahr.						
80	100°	212°	80°	80°	80°	80°	80°	80°
75	93¾	200¾	74.6	74.7	74.3	73.8	74.1	71
70	87.5	189½	69.4	69.5	68.8	67.8	68.4	62
65	81.	178¼	64.4	64.3	63.5	61.9	62.6	53.5
60	75.	167	59.3	59.1	58.3	56.2	57.1	45.8
55	68¾	155¾	54.2	53.9	53.3	50.7	51.7	38.5
50	62½	144½	49.2	48.8	48.3	45.3	46.6	32.
45	56¼	133¼	44.0	43.6	43.4	40.2	41.2	26.1
40	50	122	39.2	38.6	38.4	35.1	36.3	20.5
35	43¾	110¾	34.2	33.6	33.5	30.3	31.3	15.9
30	37½	99½	29.3	28.7	28.6	25.6	26.5	11.2
25	31¼	88¼	24.3	23.8	23.8	21.0	21.9	7.3
20	25	77	19.3	18.9	19.0	16.5	17.3	4.1
15	18¾	65¾	14.4	14.1	14.2	12.2	12.8	1.6
10	12½	54½	9.5	9.3	9.4	7.9	8.4	0.2
5	6¼	43¼	4.7	4.6	4.7	3.9	4.2	0.4
0	0	32	0.0	0.0	0.0	0.0	0.0	0.0
— 5	6¼	20¾				—3.9	—4.1	
—10	12½	9½				—7.7	—8.1	

As I consider these results of Deluc valuable, in so far as they enable us to compare directly the expansions in glass of these different thermometric liquids, I have added the two columns marked Cent. and Fahr. to give at once the reductions to the centigrade and Fahrenheit graduation. The alcohol was of such strength that its flame kindled gunpowder, and it was found that the results were not much changed by a small difference in the strength of the spirit. The brine was water saturated with common salt.

M. Biot, in the first volume of his elaborate *Traité de Physique*, has investigated several empyrical formulæ, to represent the laws of dilatation of the different fluids. They are too complex for a work of this nature. He shows that for all liquids whose dilatations have been hitherto observed, the general march of this dilatation may be represented at every temperature by an expression of this form, $\delta_t = at + bt^2 + ct^3$, in which t denotes the temperature in degrees of the mercurial thermometer; *a b c* constant coefficients, which depend on the nature of the liquid; and $^{\delta}t$ the true dilatation for the volume 1.0 from the temperature of melting ice. We shall content ourselves with giving one example, from which we may judge of the great geometrical resources of this philosopher. For olive oil the formula becomes $^{D}T = 0.95067\ T + 0.00075\ T^2 - 0.000001667\ T^3$.

The following table gives its results compared with experiment.

Of the mercurial.	Calculated.	Observed.
80°	80°	80°
70	69.64	69.41
60	59.37	59.3
50	49.2	49.2
40	39.12	39.2
30	29.15	29.3
20	19.30	19.3
10	9.58	9.5
	0.0	0.

M. Gay Lussac has lately endeavoured to discover some law which should correspond with the rate of dilatation of *different* liquids by heat. For this purpose, instead of comparing the dilatations of different liquids, above or below a temperature uniform for all, he set out from a point variable with regard to temperature, but uniform as to the cohesion of the particles of the bodies; namely, from the point at which each liquid boils under a given pressure. Among those which he examined, he found two which dilate equally from that point, viz. alcohol and sulphuret of carbon, of which the former boils at 173.14°, the latter at 115.9° Fahr. The other liquids did not present, in this respect, the same resemblance. Another analogy of the above two liquids is, that the same volume of each gives, at its boiling point, under the same atmospheric pressure, the same volume of vapour; or, in other words, that the densities of their vapours are to each other as those of the liquids at their respective boiling temperatures. The following table shows the results of this distinguished chemist.

TABLE of the Contractions of 1000 *parts in volume, by cooling.*

	Water.		Alcohol.		Sulphuret of Carb.		Ether.	
	Contract by expt.	Ditto calculated.	Contract by expt.	Ditto calculated.	Contract by expt.	Ditto calculated.	Contract by expt.	Ditto calculated.
Boiling,	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
— 5°	3.34	3.35	5.55	5.56	6.14	6.07	8.15	8.16
—10	6.61	6.65	11.43	11.24	12.01	12.08	16.17	16.01
—15	10.50	9.89	17.51	17.00	17.98	17.99	24.16	23.60
—20	13.15	13.03	24.34	23.41	23.80	23.80	31.83	30.92
—25	16.06	16.06	29.15	28.60	29.65	29.50	39.14	38.08
—30	18.85	18.95	34.74	34.37	35.06	35.05	46.42	45.04
—35	21.52	21.67	40.28	40.05	40.48	40.43	52.06	51.86
—40	24.10	24.20	45.68	45.66	45.77	45.67	58.77	58.77
—45	26.50	26.52	50.85	51.11	51.08	50.70	65.48	65.20
—50	28.56	28.61	56.02	56.37	56.28	55.52	72.01	71.79
—55	30.60	30.43	61.01	61.43	61.14	60.12	78.38	78.36
—60	32.42	31.96	65.96	66.23	66.21	64.48		
—65	34.02	33.19	10.74	70.75				
—70	35.47	34.09	75.48	74.93				
—75	36.70	34.63	80.11	78.75				

Their respective boiling points are:

Water,	-	100° Cent. =	212° F.
Alcohol,	-	78.41	173
Sulphuret of carb.		46.60	126
Sulphuric ether,		35.66	96

The experiments were made in thermometer vessels hermetically sealed.

Alcohol, at 78.41° cent. produces 488.3 its vol. of vapour.

Sulphuret of carbon, at 46.60° cent. produces 491.1 its vol. of vapour.

Ether, at 35.66° cent. produces 285.9 its vol. of vapour.

Water, at 100.00° cent. produces 1633.1 its vol. of vapour.

In solid metals, the expansion seems to be greater, the less their tenacity and density, though to this general position we have striking exceptions in antimony and bismuth, provided they were accurately measured by Smeaton's apparatus, of which, however, I have reason to doubt. The least flexure in the expanding rods, will evidently make the expansions come out too small. If metallic dilatability vary with some unknown function of density and tenacity, as is probable *a priori*, we would expect their rate of expansion to increase with the temperature. This view coincides with the following results of MM. Dulong and Petit.

Temperatures by dilatation of air.	Expansions in bulk of Iron.	Cop.	Plat.
0° to 100° cent. give	$\frac{1}{282}$	$\frac{1}{194}$	$\frac{1}{377}$
0° to 300°, mean quantity,	$\frac{1}{227}$	$\frac{1}{177}$	$\frac{1}{365}$

Tripling these denominators, we have the linear expansions, fractionally expressed thus:

	Iron.	Cop.	Plat.
0° to 100° cent.	$\frac{1}{846}$	$\frac{1}{582}$	$\frac{1}{1131}$
0° to 300° mean,	$\frac{1}{681}$	$\frac{1}{531}$	$\frac{1}{1095}$

To multiply inductive generalizations, that is, to group together *facts* which have some important qualities common to them all, is the main scope and business of philosophy. But to imagine phenomena, or to twist real phenomena into the shape suited to a preconceived constitution of things, was the vice of the Peripatetic schools, which Bacon so admirably exposed; of which in our times and studies, according to MM. Dulong and Petit, many of our speculations on the laws of heat afford a striking example.

Mr. Dalton has the merit of having first proved that the expansions of all aeriform bodies, when insulated from liquids, are uniform by the same increase of temperature; a fact of great importance to practical chemistry, which was fully verified by the independent and equally original researches of M. Gay Lussac on the subject, with a more refined and exact apparatus. Both of these philosophers demonstrated, that 100 in volume at 32° Fahr. or 0° cent. become 1.375 at 212° Fahr. or 100° cent. Hence the increment of bulk for each degree F. is $\frac{0.375}{180} = 0.002083 = \frac{1}{480}$; and for the centigrade scale it is $\frac{0.375}{100} = 0.00375 = \frac{1}{266.6}$. Thus 480 parts in volume at 32° F. become at 60° F. 480 + 28 = 508; and at 120° F. they become 480 + 88 = 568. Hence the volumes of any dry gas at these two temperatures will be to each other in the ratio of $\frac{508}{568}$. For example, 25 cubic inches at 120° F. will become 25 × $\frac{508}{568}$ = 22.36 at 60°. Or calling the volume at 32° unity = 1.00000, it will become 1.05833 at 60°, and 1.18333 at 120°. But 25 multiplied by the fraction $\frac{1.05833}{1.18333}$ = 22.36 as before. I have constructed a new table, to save much of this arithmetical operation, which will be found in the APPENDIX. Vapours, when heated out of contact of their respective liquids, obey the same law as gases; a discovery due to M. Gay Lussac.

We shall now treat of the anomaly presented by water in its dilatations by change of temperature, and then conclude this part of the subject with some practical applications of the preceding facts.

The Florentine academicians, and after them Dr. Croune, observed, that on cooling in ice and salt the bulb of a thermometric glass vessel filled with water, the liquid progressively sunk in the stem, till a certain point, after which the further progress of refrigeration was accompanied by an ascent of the liquid indicating expansion of the water. This curious phenomenon was first accurately studied by M. Deluc, who placed the apparent term of greatest density at 40° Fahr., and considered the expansion of water from that point, to vary with equal amount, by an equal change of temperature, whether of increase or decrease. Having omitted to make the requisite correction for the effect of the expansion of the glass in which the water was contained, it was found afterwards by Sir Charles Blagden and Mr. Gilpin, who introduced this correction, that the *real* term of greatest density was 39° F.

The following Table gives their experimental results.

Sp. gravity.	Bulk of water.	Temperature.		Bulk of water.	Sp. gravity.
	1.00000	39°		1.00000	
.00000	1.00000	38	40	1.00000	1.00000
0.99999	1.00001	37	41	1.00001	0.99999
.99998	1.00002	36	42	1.00002	0.99998
.99996	1.00004	35	43	1.00004	0.99996
0.99994	1.00006	34	44	1.00006	0.99994
0.99991	1.00008	33	45	1.00009	0.99991
0.99988	1.00012	32	46	1.00012	0.99988

By weighing a cylinder of copper and of glass in water at different temperatures, the maximum density comes out 40° F. Finally, Dr. Hope in 1804 published a set of experiments in the Edin. Philos. Trans. in which the complication introduced into the question by the expansion of solids, is very philosophically removed. He shows that water exposed in tall cylindrical vessels, to a freezing atmosphere, precipitates to the bottom its colder particles, till the temperature of the mass sinks to 39.5° F., after which the colder particles are found at the surface. He varied the form of the experiment by applying a zone of ice round the top, middle, and bottom of the cylinders; and in each case, delicate thermometers placed at the surface and bottom of the water, indicated that the temperature 39.5°, coincided with the maximum density. We may therefore regard the point of 40°, adopted by the French in settling their standard of weights and measures, as sufficiently exact.

The force with which solids and liquids expand or contract by heat and cold, is so prodigiously great as to overcome the strongest obstacles. Some years ago it was observed at the *Conservatoire des arts et metiers* at Paris, that the two side walls of a gallery were receding from each other, being pressed outwards by the weight of the roof and floors. Several holes were made in each of the walls, opposite to one another, and at equal distances, through which strong iron bars were introduced so as to traverse the chamber. Their ends outside of the wall were furnished with thick iron discs, firmly screwed on. These were sufficient to retain the walls in their actual position. But to bring them nearer together would have surpassed every effort of human strength. All the alternate bars of the series were now heated at once by lamps, in consequence of which they were elongated. The exterior discs being thus freed from contact of the walls, permitted them to be advanced farther, on the screwed ends of the bars. On removing the lamps, the bars cooled, contracted, and drew in the opposite walls. The other bars became in consequence loose at their extremities, and permitted their end plates to be further screwed on. The first series of bars being again heated, the above process was repeated in each of its steps. By a succession of these experiments they restored the walls to the perpendicular position; and could easily have reversed their curvature inwards, if they had chosen. The gallery still exists with its bars, to attest the ingenuity of its preserver M. Molard.

2d, *Of the change of state produced in bodies by caloric, independent of change of composition.* The three forms of matter, the solid, liquid, and gaseous, seem immediately referable to the power of heat, modifying, balancing, or subduing cohesive attraction. In the article *Blowpipe* we have shown, that every solid may be liquefied, and many of them, as well as all liquids, may be vaporized at a certain elevation of temperature. And conversely, almost every known liquid may be solidified by the reduction of its temperature. If we have not hitherto been able to convert the air and all other elastic fluids into liquids or solids, it is probably owing to the limited power we possess over thermometric depression. But we know, that many gases may be liquefied by mechanical approximation of their elastic particles, as also by cold, which must convince us that their gaseity is intimately dependent on the operation of that repulsive power.

Sulphuric ether, always a liquid in our climate, if exposed to the rigours of a Siberian winter, would become a solid, and, transported to the torrid zone, would form a permanent gas. The same transitions are familiar to us with regard to water, only its vaporizing point, being much higher, leads us at first to suppose steam an unnatural condition. But by generalizing our ideas, we learn that there is really no state of bodies which can be called more natural than another. Solidity, liquidity, the state of vapours and gases, are only accidents connected with a particular level of temperature. If we pass the easily condensed vapour of nitric acid through a red-hot glass tube, we shall convert it into gases which are incondensable by any degree of cold which we can command. The particles which formed the liquid can no longer join together to reproduce it, because their distances are changed, and with these have also changed the reciprocal attractions which united them.

Were our planet removed much further from the sun, liquids and gases would solidify; were it brought nearer that luminary, the bodies which appear to us the most solid, would be reduced into thin invisible air. We see then that the principle of heat, whatever it may be, whether matter or quality, separates the particles of bodies when its energy augments, and suffers them to approach when its power is enfeebled. By extending this view, it has been drawn into a general conclusion, that this principle was itself the force which maintains the particles of bodies *in equilibrio* against the effort of their reciprocal attraction, which tends continually to bring them together. But although this conclusion be extremely probable, we must remember that it is hypothetical, and goes further than the facts. We see that the force which balances attraction in bodies may be favoured or opposed by the principle of heat, but this does not necessarily prove that these forces are of the same nature.

The instant of equilibrium which separates the solid from the liquid state, deserves consideration. Whatever may be the cause and law of the attractions which the particles exercise on one another, the effect which results ought to be modified by their forms. When all the other qualities are equal, a particle which may be cylindrical, for example, will not exercise the same attraction as a sphere, on a point placed at an equal distance from its centre of gravity. Thus, in the law of celestial gravitation, the attraction of an ellipsoid on an exterior point will be stronger in the direction of its smaller than in that of its larger axis, at the same distance from its surface. Now, whatever be the law of attractions which holds together the particles of bodies, similar differences must exist. These particles must be attracted more strongly by certain sides than by others. Thence must result differences in the manner of their arrangement, when they are sufficiently approximated for their attractions to overcome the repulsive power. This explains to us in a very probable manner, the regular crystallization which most solid bodies assume, when they concrete undisturbed. We may easily conceive how the different substance of the particles, as well as their different forms, may produce in crystals all the varieties which we observe.

The system of the world presents magnificent effects of this attraction dependent on figure. Such are the phenomena of nutation and the precession of the equinoxes, produced by the attractions of the sun and moon on the flattened spheroid of the earth. These sublime phenomena would not have existed had the earth been a sphere: they are connected with its oblateness and rotation, in a manner which may be mathematically deduced, and subjected to calculation.

But the investigation shows, that this part of the attraction dependent on figure, decreases more rapidly than the principal force. The latter diminishes as the square of the distance; the part dependent on figure diminishes as the cube of the distance. Thus also, in the attractions which hold the parts of bodies united, we ought to expect an analogous difference to occur. Hence the force of crystallization may be subdued, before the principal attractive force is overcome. When the particles are brought to this distance, they will be indifferent to all the positions which they can assume round their centre of gravity; this will constitute the liquid condition. Suppose now that the temperature falling, the particles approach slowly to each other, and tend to solidify anew; then the forces dependent on their figure will come again into play, and in proportion as they increase, the particles solicited by these forces will take movements round their centres of gravity. They will turn towards each other their faces of greatest attraction, to arrive finally at the positions which their crystallization demands. Now, according to the figure of the particles, we may conceive that these movements may react on their centre of gravity, and cause them to approach or recede gradually from each other, till they finally give to their assemblage the volume due to the solid state; a volume which in certain cases may be greater, and in others smaller, than that which they occupied as liquids. These mechanical considerations thus explain, in the most probable and satisfactory manner, the dilatations and contractions of an irregular kind, which certain liquids, such as water and mercury, experience on approaching the term of their congelation. Having given these general views, we may now content ourselves with stating the facts as much as possible in a tabular form.

TABLE of the Concreting or Congealing Temperatures of various Liquids by FAHRENHEIT'S *Scale.*

Sulphuric ether, . .		— 46°
Liquid ammonia, . .		— 46
Nitric acid, sp. gr.	1.424	— 45.5
Sulphuric acid, sp. gr.	1.6415	— 45
Mercury		— 39
Nitric acid, sp. gr. .	1.047	— 30.1
Sulphuric acid, .	1.8064	— 26
Nitric acid, . .	1.3880	— 18.1
Do. Do. .	1.2583	— 17.7
Do. Do. .	1.3290	— 2.4
Brandy, . .		— 7.0
Sulphuric acid, .	1.8376	+ 1
Pure prussic acid, . .		4 to 5
Common salt, 25 + water	75	4
Do. 22.2 + do.	77.8	7.2
Sal ammoniac, 20 + do.	80	8
C. Salt, 20 + do.	80	9.5
Do. 16.1 + do.	83.9	13.5
Oil of turpentine, . .		14
Strong wines, . . .		20
Rochelle salt, 50 + water	50	21
C. Salt, 10 + do.	90	21.5
Oil of bergamot, . . .		23
Blood, . . .		25
C. Salt, 6.25 + water	93.75	25.5
Eps. salts, 41.6 + do.	58.4	25.5
Nitre, 12.5 + do.	87.5	26
C. Salt, 4.16 + do.	95.84	27.5
Copperas, 41.6 + do.	58.4	28
Vinegar . . .		28
Sul. of zinc, 53.3 + do.	46.7	28.6
Milk, . . .		30
Water, . . .		32
Olive oil, . . .		36
Sulphur and phosphorus, equal parts,		40
Sulphuric acid, sp. gr.	1.741	42
Do. Do.	1.780	46
Oil of anise, . . .		50
Concentrated acetic acid, .		50
Tallow, Dr. Thomson, .		92
Phosphorus, . . .		108
Stearin from hog's lard, .		109
Spermaceti, . . .		112
Tallow, Nicholson, . .		127
Margaric acid, . . .		134
Potassium, . . .		136.4
Yellow wax, . . .		142
Do. Do. . . .		149
White wax, . .		155
Sodium, . . .		194
Sulphur, Dr. Thomson, .		218
Do. Dr. Hope, . .		234
Tin, . . .		442
Bismuth, . . .		476
Lead, . . .		612
Zinc, by Sir H. Davy, .		680
Do. Brogniart, . .		698
Antimony, . . .		809?

See PYROMETER for higher heats.

The solidifying temperature of the bodies above tallow, in the table, is usually called their freezing or congealing point; and of tallow and the bodies below it, the fusing or melting point. Now, though these temperatures be stated, opposite to some of the articles, to *fractions* of a thermometric degree, it must be observed, that various circumstances modify the concreting point of the liquids, through *several* degrees; but the *liquefying* points of the same bodies, when once solidified, are uniform and fixed to the preceding temperatures.

The preliminary remarks which we offered on the forces concerned in the transition from liquidity to solidity, will in some measure explain these variations; and we shall now illustrate them by some instructive examples.

If we fill a narrow-mouthed matrass with newly distilled water, and expose it very gradually to a temperature considerably below 32°, the liquid water will be observed, by the thermometer left in it, to have sunk 10 or 11 degrees below its usual point of congelation. M. Gay Lussac, by covering the surface of the water with oil, has caused it to cool 21½ degrees Fahr. below the ordinary freezing temperature. Its volume at the same time expanded as much as if it had been heated 21½ degrees above 32°. According to Sir Charles Blagden, to whom the first of these two observations belongs, its dilatation may amount to 1-7th of the total enlargement which it receives by solidifying. Absolute repose of the liquid particles is not necessary to ensure the above phenomenon, for Sir Charles stirred water at 21° without causing it to freeze, but the least vibration of their mass, or the application of icy spiculæ, by the atmosphere, or the hand, determines an instantaneous congelation.

We may remark here, that the dilatation of the water increasing as it cools, but to a less extent than when it concretes, is a proof that its constituent particles, in obedience to the cooling process, turn their poles more and more towards the position of the maximum attraction, which constitutes their solid state. But this position may be determined instantaneously by the ready formed aqueous solid, the particles of which presenting themselves to those of the liquid, by their sides of greatest attraction, will compel them to turn into similar positions. Then the particles of the liquid first reverted will act on their neighbours like the exterior crystal, and thus from point to point the movement will be propagated through the whole mass, till all be congealed. The vibratory movement acts by throwing the particles into positions favourable for their mutual attraction.

The very same phenomena occur with saline solutions. If a hot saturated solution of Glauber's salt be cooled to 50° under a film of oil, it will remain liquid, and will bear to be moved about in the hand without any change; but if the phial containing it be placed on a vibrating table, crystallization will instantly take place. In a paper on saline crystallization which I published in the 9th number of the Journal of Science, I gave the following illustration of the above phenomena. "The effect of mechanical disturbance in determining crystallization, is illustrated by the symmetrical disposition of particles of dust and iron, by electricity and magnetism. Strew these upon a plane, and present magnetic and electric forces at a certain distance from it, no effect will be produced. Communicate to the plane a vibrating movement; the particles at the instant of being liberated from the friction of the surface, will arrange themselves according to the laws of their respective magnetic or electric attractions. The water of solution in counteracting solidity, not only removes the particles to distances beyond the sphere of mutual attraction, but probably also inverts their attracting poles." Perhaps the term *evert* would be more appropriate to liquidity, to denote an obliquity of direction in the attracting poles; and *revert* might be applied to gaseity, when a repulsive state succeeds to the feebly attractive powers of liquid particles.

The above table presents some interesting particulars relative to the acids. I have expressed their strengths, by specific gravity, from my tables of the acids, instead of by the quantity of marble which 1000 grains of them could dissolve, in the original statement of Mr. Cavendish. Under the heads of ACID (NITRIC) and EQUIVALENT, some observations will be found on these peculiarities with regard to congelation. We see that common salt possesses the greatest efficacy in counteracting the congelation of water; and next to it, sal ammoniac. Mr. Crighton, of Glasgow, whose accuracy of observation is well known, has remarked, that when a mass of melted bismuth cools in the air, its temperature falls regularly to 468°, from which term it however instantly springs up to 476°, at which point it remains till the whole be consolidated. Tin in like manner sinks and then rises 4 degrees; while melted lead, in cooling, becomes stationary whenever it descends to 612°. We shall presently find the probable cause of these curious phenomena.

Water, all crystallizable solutions, and the metals, bismuth, and antimony, expand in volume, at the instant of solidification. The greatest obstacles cannot resist the exertion of this expansive force. Thus glass bottles, trunks of trees, iron and lead pipes, even mountain rocks, are burst by the dilatation of the water in their cavities, when it is converted into ice. In the same way our pavements are raised in winter. Major Williams, of Quebec, burst bombs, which were filled with water and plugged up, by exposing them to a freezing cold. The beneficial operation of this cause is exemplified in the comminution or loosening the texture of dense clay soils, by the winter's frost, whereby the delicate fibres of plants can easily penetrate them.

There is an important circumstance occurs in the preceding experiments on the sudden congelation of a body kept liquid below its usual congealing temperature, to which we must now advert. The mass, at the moment its crystallization commences, rises in temperature to the term marked in the preceding table, whatever number of degrees it may have previously sunk below it. Suppose a globe of water suspended in an atmosphere at 21° F.; the liquid will cool and remain stationary at this temperature, till vibration of the vessel, or contact of a spicula of ice, determines its concretion, when it instantly becomes 11 degrees hotter than the surrounding medium. We owe the explanation of this fact, and its extension to many analogous chemical phenomena, to the sagacity of Dr. Black. His truly philosophical mind was particularly struck by the slowness with which a mass of ice liquefies when placed in a genial atmosphere. A lump of ice at 22° freely suspended in a room heated to 50°, which will rise to 32° in 5 minutes, will take 14 times 5, or 70 minutes, to melt into water, whose temperature will be only 32°. Dr. Black suspended in an apartment two glass globules of the same size alongside of each other, one of which was filled with ice at 32°, the other with water at 33°. In half an hour the water had risen to 40°; but it took $10\frac{1}{2}$ hours to liquefy the ice and heat the resulting water to 40°. Both these experiments concur therefore in showing that the fusion of ice is accompanied with the expenditure of 140 degrees of calorific energy, which have no effect on the thermometer. For the first experiment tells us that 10 degrees of heat entered the ice in the space of 5 minutes, and yet 14 times that period passed in its liquefaction. The second experiment shows that 7 degrees of heat entered the globes in half an hour; but 21 half hours were required for the fusion of the ice, and for heating of its water to 40°. If from the product of 7 into $21 = 147$, we subtract the 7 degrees which the water was above 33, we have 140 as before. But the most simple and decisive experiment is to mingle a pound of ice in small fragments with a pound of water at 172°. Its liquefaction is instantly accomplished, but the temperature of the mixture is only 32°. Therefore 140° of heat seem to have disappeared. Had we mixed a pound of ice-cold water with a pound of water at 172°, the resulting temperature would have been 102°, proving that the 70° which had left the hotter portion, were manifestly transferred to that which was cooler. The converse of the preceding experiments may also be demonstrated; for on suspending a flask of water, at 35° for example, in an atmosphere at 20°, if it cool to 32° in 3 minutes, it will take 140 minutes to be converted into ice of 32°; because the heat emanating at the rate of 1° per minute, it will require that time for 140° to escape. The latter experiment, however, from the inferior conducting power of ice, and the uncertainty when all is frozen, is not susceptible of the precision which the one immediately preceding admits. The tenth of 140 is obviously 14; and hence we may infer, that when a certain quantity of water, cooled to 22°, or 10° below 32°, is suddenly caused to congeal, 1-14th of the weight will become solid.

We can now understand how the thaw which supervenes after an intense frost, should so slowly melt the wreaths of snow and beds of ice, a phenomenon observable in these latitudes from the origin of time, but whose explanation was reserved for Dr. Black. Indeed, had the transition of water from its solid into its liquid state not been accompanied by this great change in its relation to heat, every thaw would have occasioned a frightful inundation, and a single night's frost would have solidified our rivers and lakes. Neither animal nor vegetable life could have subsisted under such sudden and violent transitions. Mr. Cavendish, who had discovered the above fact, before he knew of its being inculcated by Dr. Black in his lectures, states the quantity of heat which ice seems to absorb in its fusion to be 150°; Lavoisier and Laplace make it 135°; a number probably correct, from the pains they took in constructing, on this basis, their calorimeter. The fixity of the melting points of bodies exposed to a strong heat need no longer surprise us; because till the whole mass be melted, the heat incessantly introduced is wholly expended in constituting liquidity, without increasing the temperature. We can also comprehend how a liquid metal, a saline solution, or water, should in the career of refrigeration sink below the term of its congelation, and suddenly remount to it. Those substances, in which the attractive force that reverts the poles into the solid arrangement acts most slowly or feebly, will most readily permit this depression of temperature, before liquidity begins to cease. Thus bismuth, a brittle metal, takes 8° of cooling below its melting point, to determine its solidification; tin takes 4°; but lead passes so readily into the solid arrangement that its cooling is at once arrested at its fusing temperature. In illustration of this statement, we may remark, that the particles of bismuth and tin lose their cohesive attraction in a great measure long before they are heated to the melting point; though lead continues relatively cohesive till it begins to melt. Tin may be easily pulverized at a moderate elevation of temperature, and bismuth in its cold state. The instant, however, that these two metals, when melted, begin to congeal, they rise to the proper fusing temperature, because the caloric of liquidity is then disengaged.

Drs. Irvine, father and son, to both of whom the science of heat is deeply indebted, investigated the proportion of caloric disengaged by several other bodies in their passage from the liquid to the solid state, and obtained the following results:

	Caloric of liquidity.	Do. referred to the sp. heat of water.
Sulphur,	143·68	27·14
Spermaceti,	145·	
Lead,	162·	5·6
Bees' wax,	175·	
Zinc,	493·	48·3
Tin,	500·	33·
Bismuth,	550·	23·25

The quantities in the second column are the degrees by which the temperatures of each of the bodies, in its solid state, would have been raised by the heat disengaged during its concretion. An exception must be made for wax and spermaceti; which are supposed to be in the fluid state, when indicating the above elevation. Dr. Black imagined that the new relation to heat which solids acquire by liquefaction, was derived from the absorption, and intimate combination, of a portion of that fluid, which thus employing all its repulsive energies in subduing the stubborn force of cohesion, ceased to have any thermometric tension, or to be perceptible to our senses. He termed this supposed quantity of caloric, their *latent* heat; a term very convenient and proper, while we regard it simply as expressing the relation which the calorific agent bears to the same body in its fluid and solid states. To the presence of a certain portion of latent or combined heat in solids, Dr. Black ascribed their peculiar degrees of softness, toughness, malleability. Thus we know that the condensation of a metal by the hammer, or under the die, never fails to render it brittle, while, at the same time, heat is disengaged. Berthollet subjected equal pieces of copper and silver to repeated strokes of a fly press. The elevation of their temperature, which was considerable by the first blow, diminished greatly at each succeeding one, and became insensible whenever the condensation of volume ceased. The copper suffered greatest condensation, and evolved most heat. Here the analogy of a sponge, yielding its water to pressure, has been employed to illustrate the materiality of heat supposed deducible from these experiments. But the phenomenon may be referred to the intestine actions between the ultimate particles which must accompany the violent dislocation of their attracting poles. The cohesiveness of the metal is greatly impaired.

The enlarged capacity for heat, to use the popular expression, which solids acquire in liquefying, enables us to understand and apply the process of artificial cooling, by what are called freezing mixtures. When two solids, such as ice and salt, by their reciprocal affinity give birth to a liquid, then a very great demand for heat is made on the surrounding bodies, or they are powerfully stripped of their heat, and their temperature sinks of course. Pulverulent snow and salt mixed at 32°, will produce a depression of the thermometer plunged into them of about 38°. The more rapid the liquefaction, the greater the cold. Hence the paradoxical experiment of setting a pan on the fire containing the above freezing mixture with a small vessel of water plunged into it. In a few seconds the water will be found to be frozen. The solution of all crystallized salts is attended with a depression of temperature, which increases generally with the solubility of the salt.

The Table of Freezing Mixtures in the APPENDIX, presents a copious choice of such means of refrigeration. Equal parts of sal ammoniac and nitre, in powder, form the most convenient mixture for procuring moderate refrigeration; because the water of solution being afterwards removed by evaporation, the pulverized salts are equally efficacious as at first. Under the articles CLIMATE, CONGELATION, TEMPERATURE, THERMOMETER, and WATER, some additional facts will be found on the present subject.

But the diminution of temperature by liquefaction is not confined to saline bodies. When a solid amalgam of bismuth, and a solid amalgam of lead, are mixed together, they become fluid, and the thermometer sinks during the time of their action.

According to Dobereiner, if 118 grains of tin filings, 207 of lead filings, and 284 grains of pulverized bismuth (the constituents of his fusible metal), be incorporated in a dish of calendered paper, with 161·6 grains of mercury, the temperature instantly sinks from 65° to 14° . He thinks that it would sink even so low as the freezing point of mercury, were the experiment performed in a temperature somewhat under 32°.

In like manner, when 816 grains of amalgam of lead (404 mercury + 412 lead) were mixed in a temperature of 68°, with 688 grains of the amalgam of bismuth (404 mercury + 284 bismuth), the temperature suddenly fell to 30°, and by the addition of 808 grains of mercury (also at 68°), it became as low as 17°, the total depression being therefore 51°. *Ann. of Phil.* N. S. ix. 389.

The equilibrium between the attractive and repulsive forces, which constitutes the liquid condition of bodies, is totally subverted by a definite elevation of temperature, when the external compressing forces do not vary. The transition from the liquid state into that of elastic fluidity, is usually accompanied with certain explosive movements, termed ebullition. The peculiar temperature at which different liquids undergo this change is therefore called their boiling point; and the resulting elastic fluid is termed a *vapour*, to distinguish it from a *gas*, a substance permanently elastic, and not condensible as vapours are, by moderate degrees of refrigeration. It is evident that when the attractive forces, however feeble in a liquid, are supplanted by strong repulsive powers, the distances between the particles must be greatly enlarged. Thus a cubic inch of water at 40° becomes a cubic inch and 1-25th on the verge of 212°, and at 212° it is converted into 1694 cubic inches of steam. The existence of this steam indicates a balance between its elastic force and the pressure of the atmosphere. If the latter be increased beyond its average quantity by natural or artificial means, then the elasticity of the steam will be partially overcome, and a portion of it will return to the liquid condition. And conversely, if the pressure of the air be less than its mean quantity, liquids will assume elastic fluidity by a less intensity of calorific repulsion, or at a lower thermometric tension. Professor Robison performed a set of ingenious experiments, which appear to prove, that when the atmospheric pressure is wholly withdrawn, that is, *in vacuo*, liquids become elastic fluids 124° below their usual boiling points. Hence water *in vacuo* will boil and distil over at 212° — 124 = 88° Fahr. This principle was long ago employed by the celebrated Watt in his researches on the steam-engine, and has been recently applied in a very ingenious way by Mr. Tritton in his patent still, (Phil. Mag. vol. 51.), and Mr. Barry, in his evaporator for vegetable extracts, (Med. Chir. Trans. vol. 10.) See ALCOHOL, DISTILLATION, EXTRACT.

On the same principle of the boiling varying with the atmospheric pressure, the Rev. Mr. Wollaston has constructed his beautiful thermometric barometer for measuring heights. He finds that a difference of 1° in the boiling point of water is occasioned by a difference of 0·589 of an inch on the barometer. This corresponds to nearly 520 feet of difference of elevation. By using the judicious directions which he has given, the elevation of a place may thus be rigorously determined, and with great convenience. The whole apparatus, weighing 20 ounces, packs in a cylindrical tin case, 2 inches diameter, and 10 inches long.

When a vessel containing water is placed over a flame, a hissing sound or simmering is soon perceived. This is ascribed to the vibrations occasioned by the successive vaporization and condensation of the particles in immediate contact with the bottom of the vessel. The sound becomes louder as the liquid is heated, and terminates in ebullition. The temperature becomes now of a sudden stationary when the vessel is open, however rapidly it rose before, and whatever force of fire be applied. Dr. Black set a tin cup full of water at 50°, on a red hot iron plate. In four minutes it reached the boiling point, and in twenty minutes it was all boiled off. From 50° to 212°, the elevation is 162°; which interval, divided by 4, gives 40½° of heat, which entered the tin cup per minute. Hence 20 minutes, or 5 times 4 multiplied into 40½ = 810, will represent the quantity of heat that passed into the boiling water to convert it into a vapour. But the temperature of this is still only 212°. Hence, according to Black, these 810° have been expended solely in giving elastic tension, or, according to Irvine, in supplying the vastly increased capacity of the aeriform state; and therefore they may be denominated latent heat, being insensible to the thermometer. The more exact experiments of Mr. Watt have shown, that whatever period be assigned for the heating of a mass of water from 50° to 212°, 6 times this period is requisite with a uniform heat for its total vaporization. But 6 × 162° = 972 = the latent heat of steam; a result which accords with my experiments made in a different way, as will be presently shown. Every attentive operator must have observed the greater explosive violence and apparent difficulty of the ebullition of water exposed to a similar heat in glass, than in metallic vessels. M. Gay Lussac has studied this subject with his characteristic sagacity. He discovered that water boiling in a glass vessel has a temperature of 214.2°, and in a tin vessel contiguous to it, of only 212°. A few particles of pounded glass thrown into the former vessel, reduced the thermometer plunged in it to 212.6, and iron filings to 212°. When the flame is withdrawn for a few seconds from under a glass vessel of boiling water, the ebullition will recommence on throwing in a pinch of iron filings.

Professors Munche and Gmelin of Heidelberg have extended these researches, and given the curious results as to the boiling points, expressed in the following table:—

Substance of the vessels.	Ther. touching bottom.	Do. ¼ inch below surface of the water.
Silver,	211·775°	211· 55°
Platina,	211·775	210·875
Copper,	212·900	212·225
Tinned iron,	213· 24	211· 66
Marble,	212· 10	211· 66
Lead,	212· 45	211·775
Tin,	212· 7	211·775
Porcelain,	212· 1	211·900
White glass,	212· 7	212· 00
Green glass,	213· 8	213· 35
Ditto,	212· 7	212· 00
Delft ware,	213. 8	212· 7
Common earthen ware,	213· 8	212· 45

It is difficult to reconcile these variations to the results of M. Gay Lussac. "The vapour formed at the surface of a liquid," he remarks, "may be *in equilibrio* with the atmospheric pressure; while the interior portion may acquire a greater degree of heat than that of the real boiling point, provided the fluid be enclosed in a vessel, and heated at the bottom. In this case, the adhesion of the fluid to the vessel may be considered as analogous in its action to viscidity, in raising the temperature of ebullition. On this principle we explain the sudden starts which sometimes take place in the boiling of fluids. This frequently occurs to a great degree in distilling sulphuric acid, by which the vessels are not unfrequently broken when they are of glass. This evil may be effectually obviated by putting into the retort some small pieces of platina wire, when the sudden disengagement of gas will be prevented, and consequently the vessels not be liable to be broken."—*Annales de Chimie*, March 1818. See my remarks on this subject under the DISTILLATION OF SULPHURIC ACID, extracted from the Journal of Science, October 1817. If we throw a piece of paper, a crust of bread, or a powder, into a liquid slightly impregnated with carbonic acid, its evolution will be determined. See some curious observations by M. Thenard under our articles OXYGENIZED NITRIC ACID, or OXYGENIZED WATER. In a similar manner, the asperities of the surface of a glass or other vessel, act like points in electricity in throwing off gas or vapour present in the liquid which it contains.

In all the examples of the preceding table, the temperature is greater at the bottom than near the surface of the liquid; and the specific differences must be ascribed to the attractive force of the vessel to water, and its conduction of heat. We must thus try to explain why tinned iron gives a temperature to boiling water in contact with it, 1·67 degrees higher than silver and platina. Between water, and iron, tin, or lead, there are reciprocal relations at elevated temperatures, which do not apparently exist with regard to silver and platina.

M. Clement informed me in 1821, that when steam, at 212°, was made to act on sugar, or a saline powder, as that of nitre or common salt, a temperature was produced considerably greater than the steam, and, generally speaking, equal to that of a boiling hot saturated solution of the particular salt. This curious subject has been recently investigated by Mr. Farraday. The simplest way of recognising the above phenomenon is, to hold in the steam issuing from the spout of a tea-kettle, a thermometer bulb, covered with a little powdered sal ammoniac, or nitre. The temperature indicated is from 230° to 240°. The following are the temperatures produced in this way, by some substances. The first column denotes the temperatures obtained in the above method; the second, those obtained by tying the bulb up with the substance in a piece of flannel, or lint, and plunging it into an atmosphere of steam:—

Sulphate of magnesia,	218°	214°
Tartrate of potash,	236	230
Tartaric acid,	226	221
Sugar,	216°	223°
Muriate of ammonia,	230	227
Citric acid,	230	228
Nitric acid,	232	230
Nitrate of magnesia,	236	236
Nitrate of ammonia,	236	240
Acetate of potash,	244	258
Subcarbonate of potash,	258	262
Potash,	300 and upwards.	

M. Gay Lussac has remarked, that the temperature of vapour is that of the hot solution from which it rises. *Journal of Science*, xiv. 439.

The following is a tabular view of the boiling points by Fahrenheit's scale of the most important liquids, under a mean barometrical pressure of thirty inches:—

			Boiling points.
Ether, sp. gr. 0·7365 at 48°.		G. Lussac,	100°
Carburet of sulphur,		do.	113
Alcohol, sp. gr.	0·813	Ure,	173·5
Nitric acid,	1·500	Dalton,	210
Water,	.	.	212
Saturated sol. of Glaub. salt,		Biot,	213½
Do. do. sugar of lead,		do.	215½
Do. sea salt,		do.	224½
Muriate of lime 1 + water 2		Ure,	230
Do.	35·5 + do. 64·5	do.	235
Do.	40·5 + do. 59·5	do.	240
Muriatic acid,	1·094	Dalton,	232
Do.	1·127	do.	222
Do.	1·047	do.	222
Nitric acid,	1·45	do.	240
Do.	1·42	do.	248
Do.	1·40	do.	247
Do.	1·35	do.	242
Do.	1·30	do.	236
Do.	1·16	do.	220
Rectified petroleum,	.	Ure,	306
Oil of Turpentine,	.	do.	316
Sulph. acid, sp. gr.	1·30 +	Dalton,	240
Do.	1·408	do.	260
Do.	1·520	do.	290
Do.	1·650	do.	350
Do.	1·670	do.	360
Do.	1·699	do.	374
Do.	1·730	do.	391
Do.	1·780	do.	435
Do.	1·810	do.	473
Do.	1·819	do.	487
Do.	1·827	do.	501
Do.	1·833	do.	515
Do.	1·842	do.	545
Do.	1·847	do.	575
Do.	1·848	do.	590
Do.	1·849	do.	605
Do.	1·850	do.	620
Do.	1·848	Ure,	600
Phosphorus,	.	.	554
Sulphur,	.	.	570
Linseed oil,	.	.	640
Mercury, (Dulong, 662°),	.	.	656

These liquids emit vapours, which, at their respective boiling points, balance a pressure of the atmosphere equivalent to thirty vertical inches of mercury. But at inferior temperatures they yield vapours of inferior elastic power. It is thus that the vapour of quicksilver rises into the vacuum of the barometer tube; as is seen particularly in warm climates, by the mercurial dew on the glass at its summit. Hence aqueous moisture adhering to the mercury, causes it to fall below the true barometer level, by a quantity proportional to the temperature. The determination of the elastic force of vapours, in contact with their respective liquids, at different temperatures, has been the subject of many experiments. The method of measuring their elasticities, described in my paper on HEAT, seems convenient, and susceptible of precision.

A glass tube about $\frac{1}{8}$ of an inch internal diameter, and 6 feet long, is sealed at one end, and bent with a round curvature in the middle, into the form of a syphon, with its two legs parallel, and about $2\frac{1}{2}$ inches asunder. A rectangular piece of cork is adapted to the interval between the legs, and fixed firmly by twine, about 6 inches from the ends of the syphon. Dry mercury is now introduced, so as to fill the sealed leg, and the bottom of the curvature. On suspending this syphon barometer in a vertical direction, by the cork, the level of the mercury will take a position in each of the legs, corresponding to the pressure of the atmosphere. The difference is of course the true height of the barometer at the time, which may be measured by the application of a separate scale of inches and tenths. Fix rings of fine platinum wire round the tube at the two levels of the mercury. Introduce now into the tube a few drops of distilled water, recently boiled, and pass them up through the mercury. The vapour rising from the water will depress the level of the mercury in the sealed leg, and raise it in the open leg, by a quantity equal in each to one-half of the real depression. To measure distinctly this difference of level with minute accuracy, would be difficult; but the total depression, which is the quantity sought, may be readily found, by pouring mercury in a slender stream into the open leg, till the surface of the mercury in the sealed leg becomes once more a tangent to the platina ring, which is shown by a delicate film of light, as in the mountain barometer. The vertical column of mercury above the lower initial level being measured, it represents precisely the elastic force of the vapour, since that altitude of mercury was required to overcome the elasticity of the vapour. The whole object now is to apply a regulated heat to the upper portion of the sealed leg, from an inch below the mercurial level to its summit. This is easily accomplished, by passing it through a perforated cork into an inverted phial, 5 inches diameter and 7 long, whose bottom has been previously cracked off by a hot iron. Or a phial may be made on purpose. When the tapering elastic cork is now strongly pressed into the mouth of the bottle, it renders it perfectly water-tight. By inclining the syphon, we remove a little of the mercury, so that when reverted, the level in the lower leg may nearly coincide with the ring. Having then suspended it in the vertical position from a high frame, or the roof of an apartment, we introduce water at 32° into the cylindrical glass vessel. When its central tube, against the side of which the bulb of a delicate thermometer rests, acquires the temperature of the surrounding medium, mercury is slowly added to the open leg, till the primitive level is restored at the upper platina ring. The column of mercury above the ring in the open leg, is equivalent to the force of aqueous vapour at 32°. The effect of lower temperatures may be examined, by putting saline freezing mixtures in the cylinder. To procure measures of elastic force at higher temperatures, two feeble Argand flames are made to send up heated air on the opposite shoulders of the cylinder. By adjusting the flames and agitating the liquid, very uniform temperatures may be given to the tube in the axis. At every 5° or 10° of elevation, we make a measurement, by pouring mercury into the open leg, till the primitive level is restored in the other.

For temperatures above 212°, I employ the same plan of apparatus, slightly modified. The sealed leg of the syphon has a length of 6 or 7 inches, while the open leg is 10 or 12 feet long, secured in the groove of a graduated wooden prism. The initial level becomes 212° when the mercury in each leg is in a horizontal plane, and the heat is now communicated through the medium of oil. If the bending of the tube be made to an angle of about 35° from parallelism of the legs, a tubulated globular receiver becomes a convenient vessel for holding the oil. The tapering cork through which the sealed end of the syphon is passed, being thrust into the tapering mouth of the receiver, remains perfectly tight at all higher temperatures, being progressively swelled with the heat. One who has not made such trials may be disposed to cavil at the probable tightness of such a contrivance; but I who have used it in experiments for many months together, know that only extreme awkwardness in the operator can occasion the dropping out of oil heated up to even 320° of Fahrenheit. The tubulure of the receiver admits the thermometer. The Tables of Vapour, in the Appendix, exhibit the results of some carefully conducted experiments. See VAPOUR.

In my attempts to find some ratio which would connect the above elasticities of aqueous vapour with the temperatures, the following rule occurred to me:

"The elastic force at 212° = 30 being divided by 1.23, will give the force for 10° below; this quotient divided by 1.24, will give that 10° lower, and so on progressively. To obtain the forces above 212°, we have merely to multiply 30 by the ratio 1.23 for the force at 222°; this product by 1.22 for that at 232°, this last product by 1.21 for the force at 242°, and thus for each successive interval of 10° above the boiling point." The following modification of the same rule gives more accurate results. "Let *r* = the mean ratio between that of 210° and the given temperature; *n* = the number of terms (each of 10°) distant from 210; F = the elastic force of steam in inches of mercury. Then Log. of F = *Log.* 28.9 ± *n Log. r*; the positive sign being used above, the negative below 210°." I have investigated also simple ratios, which express the connexion between the temperature and elasticity of the vapours of alcohol, ether, petroleum, and oil of turpentine, for which I must refer to the paper itself.

Mr. W. Creighton of Soho communicated, in March 1819, to the Philosophical Magazine, the following ingenious formula for aqueous vapour. Let the degrees of Fahrenheit + 85 = D, and the corresponding force of steam in inches of mercury − 0.09 = I. Then *Log.* D − 2.22679 × 6 = Log. I.

Example.

212° + 85 = 297 Log. = 2.47276
− 2.22679 constant number.

0.24579
× 6

Log. 1.47582 = 29.91 = I
+0.09

Inches 30.00 D

He then gives a satisfactory tabular view of the near correspondences between the results of his formula, and my experiments.

By determining experimentally the volume of vapour which a given volume of liquid can produce at 212°, M. Gay Lussac has happily solved the very difficult problem of the specific gravity of vapours. He took a spherule of thin glass, with a short capillary stem, and of a known weight. He filled it with the peculiar liquid, hermetically sealed the orifice, and weighed it. Deducting from its whole weight the known weight of the spherule, he knew the weight, and from its sp. gravity the bulk of the liquid. He filled a tall graduated glass receiver, capable of holding about three pints, with mercury, inverted it in a basin, and let up the spherule. The receiver was now surrounded by a bottomless cylinder, which rested at its lower edge in the mercury of the basin. The interval between the two cylinders was filled with water. Heat was applied by means of a convenient bath, till the water and the included mercury assumed the temperature of 212°. The expansible liquid had ere this burst the spherule, expanded into vapour, and depressed the mercury. The height of the quicksilver column in the graduated cylinder above the level of the basin, being observed, it was easy to calculate the volume of the incumbent vapour. The quantity of liquid used was always so small, that the whole of it was converted into vapour.

The following exhibits the specific gravities as determined by the above method:

	Spec. Grav. Air at 212°, = 1		Boiling point, Fahr.
Vapour of water, -	0.62349		212°
Hydroprussic acid,	0.94760		79.7
Absolute alcohol,	1.6050		173
Sulphuric ether,	2.5860		96
Hydriodic ether,	5.4749		148
Oil of turpentine,	5.0130		316
Carburet of sulphur,	2.6447		116
Muriatic ether,	2.2190	Thenard,	52

The above specific gravities are estimated under a barometric pressure of 29.92 inches.

M. Gay Lussac has remarked, that when a liquid combination of alcohol and water, or alcohol and ether, is converted into vapour at 212° Fahr. or 100 Cent., the volume is exactly the sum of what their separate volumes would have produced; so that the condensation by chemical action in the liquid state, ceases to operate in the gaseous. An equal volume of carburet of sulphur and absolute alcohol, at their respective boiling points of 173° and 126°, is said to yield each an equal quantity of vapour of the same density. A more explicit statement has been promised, and is perhaps required on this curious subject.

It appears, that a volume of water at 40° forms 1694 volumes of steam at 212°. The subsequent increase of the volume of steam, and of other vapours, out of the contact of their respective liquids, we formerly stated to be in the ratio of the expansion of gases, forming an addition to their volume of 3-8ths for every 180° Fahrenheit. We can now infer, both from this expansion of one measure into 1694, and from the table of the elastic forces of steam, the explosive violence of this agent at still higher temperatures, and the danger to be apprehended from the introduction of water into the close moulds in which melted metal is to be poured. Hence, also, the formidable accidents which have happened, from a little water falling into heated oils. The little glass spherules, called candle bombs, exhibit the force of steam in a very striking manner; but the risk of particles of glass being driven into the eye, should cause their employment to be confined to prudent experimenters. Mr. Watt estimated the volumes of steam resulting from a volume of water at 1800; and in round numbers at 1728; numbers differing little from the above determination of M. Gay Lussac. Desaguliers' estimate of 14000 was therefore extravagant.

M. le Baron Cagniard de la Tour has lately described several curious facts concerning the production of vapours in close vessels. It had been hitherto imagined that when a liquid is confined in a Papin's digester, the internal pressure augmenting with the pressure eventually prevents the further transition of the liquid into the aeriform condition. It occurred to him that there was necessarily a limit to the dilatation of a volatile fluid, beyond which it would become vapour, notwithstanding the pressure, if the capacity of the vessel would permit the liquid matter to extend to its maximum of dilatation.

To ascertain this point, a certain quantity of alcohol, sp. gr. 0.837, and a sphere of silex, were put into a small digester, made out of the thick end of a musket barrel, the liquid occupying the third of the capacity. Having observed the sound produced by the sphere, when rolled about in the cold apparatus, it was gradually heated till a point was reached when the ball seemed to bound from end to end of the digester, as if no liquid had been present. This effect, easily distinguished by holding the end of the handle to the ear, ceased on cooling the apparatus, and was reproduced on re-heating it.

The same experiment made with water succeeded only imperfectly, because the high temperature required interfered with the lightness of the instrument. But sulphuric ether and naphtha presented the same results as alcohol.

That the phenomena might be observed with more facility, the liquids were introduced into small tubes of glass, and hermetically sealed. A handle of glass was attached to each tube. A tube was two fifths filled with alcohol, and then slowly and carefully heated; as the liquid dilated its mobility increased, and when its volume was nearly doubled, it completely disappeared, and became a vapour so transparent, that the tube appeared quite empty. On leaving it to cool for a moment, a very thick cloud formed in its interior, and the liquid returned to its first state. A second tube, nearly half occupied by the same fluid, gave a similar result; but a third, containing rather more than half, burst.

Similar experiments made with naphtha, sp. gr. 0.807, and with ether, gave similar results. Ether required less space than naphtha, and naphtha less than alcohol, to become vapour; appearing to indicate that the more a body is already dilated, the less additional volume does it require, before it attains its maximum of expansion.

In all the above experiments the air had been expelled from the tubes; but, repeated with others in which the air was left, the results were similar, and the phenomena more readily observed, from the absence of ebullition.

A last trial was made with water in a tube of glass, about one third of its capacity being occupied by the fluid. This tube lost its transparency, and broke a few instants after. It appears that by a high temperature, water is able to decompose glass, by separating the alkali; leading to the supposition that other interesting chemical results may be obtained, by multiplying the applications of this process of decomposition.

On carefully watching the tubes in which air had been left, it was remarked that those in which the fluid had not space for the maximum of dilatation preceding the conversion into vapour, did not always break as soon as the liquid appeared to fill the whole space; and that the explosion was the more tardy, as the excess of liquid above that required to fill the space, was less. May not then the inference be drawn, that liquids but little compressible at low temperatures, become much more so at high temperatures?

Alcohol, naphtha, and sulphuric ether, submitted to heat with pressure, are converted into vapour in a space a little more than double that of each liquid.

An augmentation of pressure, occasioned by the presence of air, causes no obstacle to the evaporation of the liquid in the same space, but only renders the dilatation of the liquid more regular and observable.

Water, though susceptible of being reduced into very compressed vapour, has not yet been submitted to perfect experiments, because of the imperfect closing of the digester at high temperatures, and also because of its action on glass tubes.

M. Cagniard de la Tour bent a tube into a syphon, placed ether in one leg, and separated it from the other leg containing air, by mercury; both legs being then sealed, the apparatus was heated, and when the ether became vapour, the diminution in the bulk of the air was marked. In three repetitions of the experiment 528 parts became 14. Ether is therefore susceptible of being converted into vapour in a space less than twice its original volume, and in this state it exercises a pressure of between 37 and 38 atmospheres.

When alcohol, sp. gr. 0.837, was used, 476 parts of air became 4; and from an observation of the volume, it was ascertained that alcohol may be reduced into vapour, in a space rather less than thrice its original volume, and that then it exerts a pressure of 119 atmospheres.

The temperature at which these effects took place was ascertained, by repeating the experiments in an oil bath. The ether required a temperature of 320° F.; alcohol, that of 405°F.

A small quantity of carbonate of soda added to the water, prevented, to a certain degree, its altering the transparency of the glass tubes. Hence he was enabled to ascertain that at a temperature not far from that of melting zinc, water could be converted into vapour, in a space nearly four times its original volume. *Annales de Chimie*, xxi. 178.

It has been already mentioned, that the caloric of fluidity in steam surpasses that of an equal weight of boiling water by about 972°. This quantity, or the latent heat of steam, as it is called, is most conveniently determined, by transmitting a certain weight of it into a given weight of water, at a known temperature, and from the observed elevation of temperature in the liquid deducing the heat evolved during condensation. Dr. Black, Mr. Watt, Lavoisier, Count Rumford, Clement, and Desormes, as well as myself, have published observations on the subject. "In this research I employed a very simple apparatus; and with proper management, I believe, it is capable of giving the absolute quantities of latent heat in different vapours, as exactly as more refined and complicated mechanisms. At any rate, it will afford comparative results with great precision. It consisted of a glass retort of very small dimensions, with a short neck, inserted into a globular receiver of very thin glass, and about three inches in diameter. The globe was surrounded with a certain quantity of water at a known temperature, contained in a glass basin. 200 grains of the liquid, whose vapour was to be examined, were introduced into the retort, and rapidly distilled into the globe by the heat of an Argand lamp: The temperature of the air was 45°, that of the water in the basin from 42° to 43°, and the rise of temperature occasioned by the condensation of the vapour never exceeded that of the atmosphere by four degrees. By these means, as the communication of heat is very slow between bodies which differ little in temperature, I found that the air could exercise no perceptible influence on the water in the basin during the experiment, which was always completed in five or six minutes. A thermometer of great delicacy was continually moved through the water; and its indications were read off, by the aid of a lens, to small fractions of a degree.

"In all the early experiments of Dr. Black on the latent heat of common steam, the neglect of the above precautions introduced material errors into the estimate. Hence that distinguished philosopher found the latent heat of steam to be no more than 800° or 810°. Mr. Watt afterwards determined it more nearly at from 900° to 970°, Lavoisier and Laplace have made it 1000°, and Count Rumford 1040°.

"From the smallness of the retort in my mode of proceeding, the shortness of the neck, and its thorough insertion into the globe, we prevent condensation by the air *in transitu;* while the surface of the globe, and the mass of water being great, relative to the quantity of vapour employed, the heat is entirely transferred to the refrigeratory, where it is allowed to remain without apparent diminution for a few minutes.

"In numerous repetitions of the same experiment the accordances were excellent. The following table contains the mean results. The water in the basin weighed in each case 32340 grs., and 200 grs. of each liquid was distilled over. The globe was held steadily in the centre of the globe by a slender ring fixed round the neck." For the arithmetical reductions I must refer to the paper itself. But I have found since, that a compensation was due for the glass basin itself, which I omitted by accident to introduce into the arithmetical reductions. This would have raised the latent heat of water to very nearly 1000, and that of the other vapours in a proportional degree. I now give the original table along with a corrected column:

Table of Latent Heat of Vapours.

		Corrected Column.
Vapour of water, at its boiling point . .	967°	1000°
Alcohol, sp. gr. 825 . . .	442	457
Ether, boiling point 112° . .	302.4	312.9
Petroleum	177.8	183.8
Oil of turpentine	177.8	183.8
Nitric acid, sp. gr. 1.494, boiling point 165°	532.	550.
Liquid ammonia, sp. gr. 0.978 .	837.3	865·9
Vinegar, sp. gr. 1.007 . . .	875.0	903

"Aqueous vapour of an elastic force balancing the atmospheric pressure, has a specific gravity compared to air, by the accurate experiments of M. Gay Lussac, of 10 to 16. For facility of comparison, let us call the steam of water unity, or 1.00; then the specific gravity of the vapour of pure ether is 4.00, while the specific gravity of the vapour of absolute alcohol is 2.60. But the vapour of ether, whose boiling point is not 100°, but 112°, like the above ether, contains some alcohol; hence we must accordingly diminish a little the specific gravity number of its vapour. It will then become, instead of 4.00, 3.55. Alcohol of 0.825 sp. gr. contains much water; sp. gr. of its vapour, 2.30. That of water, as before unity, 1.00. The interstitial spaces in these vapours will therefore be inversely as these numbers, or $\frac{1}{355}$ for ether, $\frac{1}{230}$ for alcohol, $\frac{1}{100}$ for water. Hence, $\frac{1}{355}$ of latent heat existing in ethereal vapour, will occupy a proportional space, be equally condensed, or possess the same tension with $\frac{1}{230}$ in alcoholic, and $\frac{1}{100}$ in aqueous vapour. A small modification will no doubt be introduced by the difference of the thermometric tensions, or sensible heats, under the same elastic force. Common steam, for example, may be considered as deriving its total elastic energy from the latent heat multiplied into the specific gravity + the thermometric tension.

"Hence, the elastic force of the vapours of water, ether, and alcohol, are as follows:—

$$E_{w} = 970 \times 1.00 + 212^\circ = 1182$$

$$E_{e} = 302 \times 3.55 + 112^\circ = 1184$$

$$E_{al} = 440 \times 2.30 + 175^\circ = 1185$$

Three equations, which yield, according to my general proposition, equal quantities. When the elastic forces of vapours are doubled, or when they sustain a double pressure, their interstices are proportionably diminished. We may consider them now, as in the condition of vapours possessed of greater specific gravities. Hence the second portion of heat introduced to give double the elastic force, need not be equal to the first, in order to produce the double tension.

"This view accords with the experiments of Mr. Watt, alluded to in the beginning of the memoir. He found, that the latent heat of steam is less when it is produced under a greater pressure, or in a more dense state; and greater when it is produced under a less pressure, or in a less dense state. Berthollet thinks this fact so unaccountable, that he has been willing to discard it altogether. Whether the view I have just opened, of the relation subsisting between the elastic force, density, and latent heat of different vapours, harmonize with chemical phenomena in general, I leave others to determine. It certainly agrees with that *unaccountable* fact. Whatever be the fate of the general law now respectfully offered, the statement of Mr. Watt may be implicitly received under the sanction of his acknowledged sagacity and candour." *Ure's Researches on Heat*, pp. 54 and 55.

M. Clement inserted a pipe connected with a steam boiler capable of bearing high pressure into a given quantity of water at a certain temperature, contained in a bucket. He now turned the stop-cock on the pipe, and allowed a certain quantity of steam at 212° F. *to enter.* He then noted the increase of temperature which the water had received. He repeated the experiment; only the steam in the boiler and that which issued through the pipe, had been heated till its elasticity was double of that at 212°. As soon as the water in the bucket indicated, by its increase of volume, that the same quantity of steam had been condensed as in the first experiment, he shut the stop-cock and measured the temperature of the bucket. He found it to be the same as before. A third experiment with steam having an elastic force equal to three atmospheres, was next subjected to examination; and he found the same result. Hence he inferred that equal weights of steam, incumbent over water, at whatsoever temperature, contain the same quantity of heat; or, in popular language, that the total heat of steam is a constant quantity: for, in proportion as the sensible heat augments, the latent or specific heat diminishes. On this proposition he has founded a luminous theory of steam engines, which, we hope, he will soon present to the world in his promised *Traité de Chaleur.*

As it is the vastly greater relation to heat which steam possesses above water, that makes the boiling point of that liquid so perfectly stationary in open vessels, over the strongest fires, we may imagine that other vapours which have a smaller latent heat, may not be capable, by their formation, of keeping the ebullition of their respective liquids at a uniform temperature. I observed this variation of the boiling point actually to happen with oil of turpentine, petroleum, and sulphuric acid. When these liquids are heated briskly in apothecaries' phials, they rise 20 or 30 degrees above the ordinary point at which they boil in hemispherical capsules. Hence, also, their vapours being generated with little heat, are apt to rise with explosive violence. Oil of turpentine varies, moreover, in its boiling point, according to its freshness and limpidity. It is needless, therefore, to raise an argument on a couple of degrees of difference. But, in Dr. Murray's, and all our other chemical systems published prior to 1817, 560° was assigned as the boiling point of this volatile oil. Mr. Dalton's must be excepted, for he says, "several authors have it, that oil of turpentine boils at 560°. I do not know how the mistake originated, but it boils below 212°, like the rest of the essential oils."

From the above quotation, it may be inferred, that the conversion at all temperatures, however low, of any liquid or solid whatever, into a vapour, is uniformly accompanied with the abstraction of heat from surrounding bodies, or in popular language, the production of cold; and that the degree of refrigeration will be proportional to the capacity of the vapour for heat, and the rapidity of its formation. The application of this principle to the uses of life, first suggested by Drs. Cullen and Black, has been improved and extended by Mr. Leslie. We shall describe his methods under CONGELATION.

It appears, moreover, probable, that the permanent gases have the same superior relation to heat with the vapours. *Hence*, their transition to the liquid or solid states ought to be attended with the evolution of heat. Accordingly, in the combustion of hydrogen, phosphorus, and metals, gaseous matter is copiously fixed; to which cause Black and Lavoisier ascribed the whole of the heat and light evolved. We shall see, however, in the article COMBUSTION, many difficulties to the adoption of this plausible hypothesis. The best illustration of the common notion as to the latent heat of gases, is afforded by the condensed air tinder-tube; in which mechanical compression appears to extrude from cold air, its latent stores of both heat and light. A glass tube, eight inches long, and a half inch wide, of uniform calibre, shut at one end, and fitted with a short piston, is best adapted for the exhibition of this pleasing experiment. When the object, however, is merely to kindle agaric tinder, a brass tube 3-8ths wide and 4½ inches long will suffice. A dexterous condensation of air into 1-5th of the volume, produces the heat of ignition.

Under the head of specific heat, it has been shown to diminish in a gas more rapidly than the diminution of its volume; and therefore heat will be disengaged by its condensation, whether we regard the phenomenon as the expulsion of a fluid, or intense actions excited among the particles by their violent approximation. The converse of the above phenomenon is exhibited on a great scale, in the Schemnitz mines of Hungary. The hydraulic machine for draining them consists essentially of two strong air-tight copper cylinders, 96 feet vertically distant from each other, and connected by a pipe. The uppermost, which is at the mouth of the pit, can be charged with water by the pressure of a reservoir, elevated 136 feet above it. The air suddenly dislodged by this vast hydrostatic pressure, is condensed through the pipe, on the surface of the water standing in the lower cylinder, which it forces up a rising water-pipe to the surface, and then takes its place. When the stopcocks are turned to recharge the lower cylinder with water, the imprisoned air expanding to its natural volume, absorbs the heat so powerfully, as to convert the drops of water that issue with it into hail and snow. M. Gay Lussac has lately proposed a miniature imitation of this machine for artificial refrigeration. He exposes the small body to be cooled to a stream of air escaping by a small orifice, from a box in which it had been strongly condensed. In the autumn of 1816, I performed an analogous experiment in the house of M. Breguet, in Paris. This celebrated artist having presented me with one of his elegant metallic thermometers, I immediately proposed to determine, by means of it, the heat first abstracted, and subsequently disengaged in the exhaustion of air, and its readmission into the receiver of an air-pump. MM. Breguet politely favoured me with their assistance, and the use of their excellent air-pump. Having enclosed in the receiver their thermometer, and a delicate one by Crighton, which I happened to have with me, we found, on rapidly exhausting the receiver, that M. Breguet's thermometer indicated a refrigeration of 50° F. while Crighton's sunk only 7°. After the two had arrived at the same temperature, the air was rapidly admitted into the receiver. M. Breguet's thermometer now rose 50°, while Crighton's mounted 7° as before. See THERMOMETER.

Dr. Darwin has ingeniously explained the production of snow on the tops of the highest mountains, by the precipitation of vapour from the rarefied air which ascends from plains and valleys. "The Andes," says Sir H. Davy, "placed almost under the line, rise in the midst of burning sands; about the middle height is a pleasant and mild climate; the summits are covered with unchanging snows; and these ranges of temperature are always distinct: the hot winds from below, if they ascend, become cooled in consequence of expansion; and the cold air, if by any force of the blast it is driven downwards, is condensed, and rendered warmer as it descends."

Evaporation and rarefaction, the grand means employed by nature to temper the excessive heats of the torrid zone, operate very powerfully among mountains and seas. But the level sands are devoured by unmitigated heat. In milder climates, the fervours of the solstitial sun are assuaged by the vapours copiously raised from every river and field, while the wintry cold is moderated by the condensation of atmospheric vapours in the form of snow.

The equilibrium of animal temperature is maintained by the copious discharge of vapour from the lungs and the skin. The suppression of this exhalation is a common cause of many formidable diseases. Among these, fever takes the lead. The ardour of the body in this case of suppressed perspiration, sometimes exceeds the standard of health by six or seven degrees. The direct and natural means of allaying this morbid temperature were first systematically enjoined by Dr. Currie of Liverpool. He showed, that the dashing or affusion of cold water on the skin of a fever patient, has most sanitary effects, when the heat is steadily above 98°, and when there is no sensation of chilliness, and no moisture on the surface. Topical refrigeration is elegantly procured, by applying a piece of muslin or tissue paper to any part of the skin, and moistening it with ether, carburet of sulphur, or alcohol. By pouring a succession of drops of ether on the surface of a thin glass tube containing water, a cylinder of ice may be formed at midsummer. The most convenient plan which the chemist can employ, to free a gas from vapour, is to pass it slowly through a long tortuous tube wrapt in porous paper wetted with ether.

On the other hand, when he wishes to expose his vessels to a regulated heat, he makes hot vapour be condensed on their cold surface. The heat thus disengaged from the vapour, passes into the vessel, and speedily raises it to a temperature which he can adjust with the nicest precision. A vapour bath ought therefore to be provided for every laboratory. That which I got constructed a few years ago for the Institution, is so simple and efficacious as to merit a description.—A square tin box, about 18 inches long, 12 broad, and 6 deep, has its bottom hollowed a little by the hammer towards its centre, in which a round hole is cut of five or six inches diameter. Into this, a tin tube three or four inches long is soldered. This tube is made to fit tightly into the mouth of a common tea-kettle, which has a folding handle. The top of the box has a number of circular holes cut into it, of different diameters, into which evaporating capsules of platina, glass, or porcelain, are placed. When the kettle, filled with water, and with its nozzle corked, is set on a stove, the vapour, playing on the bottoms of the capsules, heats them to any required temperature; and being itself continually condensed, it runs back into the kettle to be raised again, in ceaseless cohobation. With a shade above, to screen the vapour chest from soot, the kettle may be placed over a common fire. The orifices not in use are closed with tin lids. In drying precipitates, I cork up the tube of the glass funnel, and place it, with its filter, directly into the proper sized opening. For drying red cabbage, violet petals, &c. a tin tray is provided, which fits close on the top of the box, within the rim which goes about it. The round orifices are left open when this tray is applied. Such a form of apparatus is well adapted to inspissate the pasty mass from which lozenges and troches are to be made.

But the most splendid trophy erected to the science of caloric, is the steam-engine of Watt. This illustrious philosopher, from a mistake of his friend Dr. Robison, has been hitherto deprived of a part of his claims to the admiration and gratitude of mankind. The fundamental researches on the constitution of steam, which formed the solid basis of his gigantic superstructure, though they coincided perfectly with Dr. Black's results, were not drawn from them. In some conversations with which this great ornament and benefactor of his country honoured me a short period before his death, he described, with delightful *naïveté*, the simple, but decisive experiments, by which he discovered the latent heat of steam. His means and his leisure not then permitting an expensive and complex apparatus, he used apothecaries' phials. With these, he ascertained the two main facts, first, that a cubic inch of water would form about a cubic foot of ordinary steam, or 1728 inches; and that the condensation of that quantity of steam would heat six cubic inches of water from the atmospheric temperature to the boiling point. Hence he saw that six times the difference of temperature, or fully 900° of heat, had been employed in giving elasticity to steam; which must be all abstracted before a complete vacuum could be procured under the piston of the steam-engine. These practical determinations he afterwards found to agree pretty nearly with the observations of Dr. Black. Though Mr. Watt was then known to the Doctor, he was not on those terms of intimacy with him which he afterwards came to be, nor was he a member of his class.

Mr. Watt's three capital improvements, which seem to have nearly exhausted the resources of science and art, were the following; 1. The separate condensing chest, immersed in a body of cold water, and connected merely by a slender pipe with the great cylinder, in which the impelling piston moved. On opening a valve or stop-cock of communication, the elastic steam which had floated the ponderous piston, rushed into the distant chest with magical velocity, leaving an almost perfect vacuum in the cylinder, into which the piston was forced by atmospheric pressure. What had appeared impossible to all previous engineers was thus accomplished. A vacuum was formed without cooling the cylinder itself. Thus it remained boiling hot, ready the next instant to receive and maintain the elastic steam. 2. His second grand improvement consisted in closing the cylinder at top, making the piston rod slide through a stuffing box in the lid, and causing the steam to give the impulsive pressure, instead of the atmosphere. Henceforth the waste of heat was greatly diminished. 3. The final improvement was the double impulse, whereby the power of his engines, which was before so great, was in a moment more than doubled. The counterweight required in the single stroke engine, to depress the pump-end of the working beam, was now laid aside. He thus freed the machine from a dead weight or drag of many hundred pounds, which had hung upon it from its birth, about seventy years before.

The application of steam to heat apartments, is another valuable fruit of these studies. Safety, cleanliness, and comfort, thus combine in giving a genial warmth for every purpose of private accommodation, or public manufacture. It has been ascertained, that *one cubic foot* of boiler will heat about *two thousand feet* of space in a cotton mill whose average heat is from 70° to 80° Fahr. And if we allow 25 cubic feet of a boiler for a horse's power in a steam-engine supplied by it, such a boiler would be adequate to the warming of fifty thousand cubic feet of space. It has been also ascertained, that one square foot of surface of steam pipe, is adequate to the warming of two hundred cubic feet of space. This quantity is adapted to a well-finished ordinary brick or stone building. The safety valve on the boiler should be loaded with 2½ pounds for an area of a square inch, as is the rule for Mr. Watt's engines. Cast iron pipes are preferable to all others for the diffusion of heat. Freedom of expansion must be allowed, which in cast iron may be taken at about a tenth of an inch for every ten feet in length. The pipes should be distributed within a few inches of the floor.

Steam is now used extensively for drying muslin and calicoes. Large cylinders are filled with it, which, diffusing in the apartment a temperature of 100° or 130°, rapidly dry the suspended cloth. Occasionally the cloth is made to glide in a serpentine manner *closely* round a series of steam cylinders, arranged in parallel rows. It is thus safely and thoroughly dried in the course of a minute. Experience has shown, that bright dyed yarns, like scarlet, dried in a common *stove* heat of 128°, have their colour darkened, and acquire a harsh feel; while similar hanks, laid on a *steam* pipe heated up to 165°, retain the shade and lustre they possessed in the wetted state. The people who work in steam drying-rooms are healthy; those who were formerly employed in the stove-heated apartments, became soon sickly and emaciated. These injurious effects must be ascribed to the action of cast iron at a high temperature on the atmosphere.

The heating by steam of large quantities of water or other liquids, either for baths or manufactures, may be effected in two ways: that is, the steam pipe may be plunged with an open end into the water cistern; or the steam may be diffused around the liquid in the interval between the wooden vessel and an interior metallic case. The second mode is of universal applicability. Since a gallon of water in the form of steam will heat 6 gallons at 50°, up to the boiling point, or 162°; 1 gallon of the former will be adequate to heat 18 gallons of the latter up to 100°, making a liberal allowance for waste in the conducting pipe.

Cooking of food for man and cattle is likewise another useful application of steam; "for," says Dr. Black, "it is the most effectual carrier of heat that can be conceived, and will deposit it only on such bodies as are colder than boiling water." Hence in a range of pots, whenever the first has reached the boiling point, but no sooner, the steam will go onwards to the second, then to the third, and thus in succession. Inspection of the last will therefore satisfy us of the condition of the preceding vessels. Distillation has been lately practised, by surrounding the still with a strong metallic case, and filling the interstice with steam heated up to 260° or 280°. But notwithstanding of safety valves, and every ordinary attention, dangerous explosions have happened. Distillation *in vacuo*, by the heat of external steam of ordinary strength, would be a safe and elegant process. The old, and probably very exact experiments of Mr. Watt on this subject, do not lead us, however, to expect any saving of fuel, merely by the *vacuum* distillation. "The unexpected result of these experiments is, that there is no advantage to be expected in the manufacture of ardent spirits by distillation *in vacuo*. For we find, that the latent heat of the steam is at least as much increased as the sensible heat is diminished."—*Dr. Black's Lectures*, vol. i. p. 190.

By advantage is evidently meant saving of fuel. But in preparing spirits, ethers, vinegars, and essential oils, there would undoubtedly be a great advantage relative to flavour. Every risk of *empyreuma* is removed.

Chambers filled with steam heated to about 125° Fahr. have been introduced with advantage into medicine, under the name of vapour baths. Dry air has also been used. It can be tolerated at a much greater heat than moist air; see TEMPERATURE. A large cradle, containing saw-dust heated with steam, should be kept in readiness at the houses erected by the Humane Society for the recovery of drowned persons; or a steam chamber might be attached to them for this purpose, as well as general medicinal uses.

I have thus completed what I conceive to belong directly to caloric in a chemical dictionary. Under *alcohol*, *attraction*, *blowpipe*, *climate*, *combustion*, *congelation*, *digester*, *distillation*, *electricity*, *gas*, *light*, *pyrometer*, *thermometer*, *water*, some interesting correlative facts will be found.

CALORIMETER. An instrument contrived by Lavoisier and Laplace, to measure the heat given out by a body in cooling, from the quantity of ice it melts. It consists of three vessels, one placed within the other, so as to leave two cavities between them; and a frame of iron network, to be suspended in the middle of the inner vessel. This network is to hold the heated body. The two exterior concentric interstices are filled with bruised ice. The outermost serves to screen from the atmosphere the ice in the middle space, by the fusion of which the heat given out by the central hot body is measured. The water runs off through the bottom, which terminates in the shape of a funnel, with a stop-cock.

CALP. An argillo-ferruginous limestone.

CAMELEON MINERAL. When pure potash and black oxide of manganese are fused together in a crucible, a compound is formed, whose solution in water, at first green, passes spontaneously through the whole series of coloured rays to the red. From this latter tint, the solution may be made to retrograde in colour to the original green, by the addition of potash; or it may be rendered altogether colourless, by adding either sulphurous acid or chlorine to the solution, in which case there may or may not be a precipitate, according to circumstances. MM. Chevillot and Edouard have lately read some interesting memoirs on this substance, before the Academy of Sciences. They found, that when potash and the green oxide of manganese were heated in close vessels, containing azote, no cameleon is formed. The same result followed with the brown oxide, and ultimately with the black. They therefore ascribe the phenomena to the absorption of oxygen, which is greatest when the oxide of manganese equals the potash in weight. They regard it as a manganesiate of potash, though they have hitherto failed in their attempts to separate this supposed tetroxide, or manganesic acid. When acids are poured upon the *green* cameleon, or an alkali upon the *red*, they are equally changed from one colour to the other; even boiling and agitation are sufficient to disengage the excess of potash in the green cameleon, and to change it into red. Many acids also, when used in excess, decompose the cameleon entirely, by taking the potash from it, disengaging the oxygen, and precipitating the manganese in the state of black oxide. Sugar, gums, and several other substances, capable of taking away the oxygen, also decompose the cameleon, and an exposure to the air likewise produces the same effect. Soda, barytes, and strontites, also afford peculiar cameleons. The red potash cameleon is perfectly neutral. Phosphorus brought in contact with it, produces a detonation; and it sets some other combustibles on fire. Exposed alone to heat, it is resolved into oxygen, black oxide of manganese, and green cameleon, or submanganesiate of potash.

CAMPEACHY WOOD. See LOGWOOD.

CAMPHOR. There are two kinds grow in the East, the one produced in the islands of Sumatra and Borneo, and the other produced in Japan and China.

Camphor is extracted from the roots, wood, and leaves of two species of laurus, the roots affording by far the greatest abundance. The method consists in distilling with water in large iron pots, serving as the body of a still, with earthen heads adapted, stuffed with straw, and provided with receivers. Most of the camphor becomes condensed in the solid form among the straw, and part comes over with the water.

The sublimation of camphor is performed in low flat-bottomed glass vessels placed in sand; and the camphor becomes concrete in a pure state against the upper part, whence it is afterwards separated with a knife, after breaking the glass. Lewis asserts, that no addition is requisite in the purification of camphor; but that the chief point consists in managing the fire, so that the upper part of the vessel may be hot enough to bake the sublimate together into a kind of cake. Chaptal says, the Hollanders mix an ounce of quicklime with every pound of camphor previous to the distillation.

Purified camphor is a white concrete crystalline substance, not brittle, but easily crumbled, having a peculiar consistence resembling that of spermaceti, but harder. It has a strong lively smell, and an acrid taste; is so volatile as totally to exhale when left exposed in a warm air; is light enough to swim on water; and is very inflammable, burning with a very white flame and smoke, without any residue.

The roots of zedoary, thyme, rosemary, sage, the inula helenium, the anemony, the pasque flower or pulsatilla, and other vegetables, afford camphor by distillation. It is observable, that all these plants afford a much larger quantity of camphor, when the sap has been suffered to pass to the concrete state by several months' drying. Thyme and peppermint, slowly dried, afford much camphor; and Mr. Achard has observed, that a smell of camphor is disengaged when volatile oil of fennel is treated with acids.

Mr. Kind, a German chemist, endeavouring to incorporate muriatic acid gas with oil of turpentine, by putting this oil into the vessels in which the gas was received when extricated, found the oil change first yellow, then brown, and lastly, to be almost wholly coagulated into a crystalline mass, which comported itself in every respect like camphor. Tromsdorff and Boullay confirm this. A small quantity of camphor may be obtained from oil of turpentine by simple distillation at a very gentle heat. Other essential oils, however, afford more. By evaporation in shallow vessels, at a heat not exceeding 57° F., Mr. Proust obtained from oil of lavender .25, of sage .21, of marjoram .1014, of rosemary .0625. He conducted the operation on a pretty large scale.

Camphor is not soluble in water in any perceptible degree, though it communicates its smell to that fluid, and may be burned as it floats on its surface. It is said, however, that a surgeon at Madrid has effected its solution in water by means of the carbonic acid.

Camphor may be powdered by moistening it with alcohol, and triturating it till dry. It may be formed into an emulsion by previous grinding with near three times its weight of almonds, and afterwards gradually adding the water. Yolk of egg and mucilages are also effectual for this purpose; but sugar does not answer well.

It has been observed by Romieu, that small pieces of camphor floating on water have a rotatory motion.

Alcohol, ethers, and oils, dissolve camphor.

The addition of water to the spirituous or acid solutions of camphor, instantly separates it.

Mr. Hatchett has particularly examined the action of sulphuric acid on camphor. A hundred grains of camphor were digested in an ounce of concentrated sulphuric acid for two days. A gentle heat was then applied, and the digestion continued for two days longer. Six ounces of water were then added, and the whole distilled to dryness. Three grains of an essential oil, having a mixed odour of lavender and peppermint, came over with the water. The residuum being treated twice with two ounces of alcohol each time, fifty-three grains of a compact coal in small fragments remained undissolved. The alcohol, being evaporated in a water bath, yielded forty-nine grains of a blackish-brown substance, which was bitter, astringent, had the smell of caromel, and formed a dark brown solution with water. This solution threw down very dark brown precipitates, with sulphate of iron, acetate of lead, muriate of tin, and nitrate of lime. It precipitated gold in the metallic state. Isinglass threw down the whole of what was dissolved in a nearly black precipitate.

When nitric acid is distilled repeatedly in large quantities from camphor, it converts it into a peculiar acid. See Acid (Camphoric).

Camphor melts at 288°, and boils at the temperature of 400°. By my analysis camphor is composed, in 100 parts, of 77.38 carbon, 11.14 hydrogen, and 11.48 oxygen. It is therefore nearly represented by

Carbon	10 atoms	7.5	78.02
Hydrogen	9	1.125	11.58
Oxygen	1	1.	10.40
		9.625	100.00

or, 9 atoms olefiant gas + 1 atom carbonic acid.

As an internal medicine, camphor has been frequently employed in doses from 5 to 20 grains, with much advantage, to procure sleep in mania, and to counteract gangrene. Though a manifest stimulant, when externally applied, it appears from the reports of Cullen and others, rather to diminish the animal temperature and the frequency of the pulse. In large doses it acts as a poison, an effect best counteracted by opium. It is administered to alleviate the irritating effects of cantharides, mezereon, the saline preparations of mercury and drastic purgatives. It lessens the nauseating tendency of squill, and prevents it from irritating the bladder. It is employed externally as a discutient. Its effluvia are very offensive to insects, on which account it is much used to defend subjects of natural history from their ravages.

CANCER (MATTER OF). This morbid secretion was found by Dr. Crawford to give a green colour to syrup of violets, and, treated with sulphuric acid, to emit a gas resembling sulphuretted hydrogen, which he supposes to have existed in combination with ammonia in the ulcer. Hence the action of virulent pus on metallic salts. He likewise observed, that its odour was destroyed by aqueous chlorine, which he therefore recommends for washing cancerous sores.

CANDLES. Cylinders of tallow or wax, containing in their axis a spongy cord of cotton or hemp. A few years ago I made a set of experiments on the relative intensities of light, and duration of different candles, the result of which is contained in the following table.

Number in a Pound.	Duration of a Candle.	Weight in grains.	Consumption per hour, grains.	Proportion of light.	Economy of Light.	Candles equal one argand.
10 mould,	5 h. 9 m.	682	132	12¼	68	5.7
10 dipped,	4 36	672	150	13	65½	5.25
8 mould,	6 31	856	132	10½	59½	6.6
6 do.	7 2⅓	1160	163	14⅖	66	5.0
4 do.	9 36	1787	186	20¼	80	3.5
Argand oil flame.			512	69.4	100	

A Scotch mutchkin or 1-8th of a gallon of good seal oil, weighs 6010 gr. or 13 and 1-10th oz. avoirdupois, and lasts in a bright argand lamp 11 hours 44 minutes. The weight of oil it consumes per hour is equal to four times the weight of tallow in candles 8 to the pound, and 3½ times the weight of tallow in candles 6 to the pound. But its light being equal to that of 5 of the latter candles, it appears from the above table, that 2 pounds weight of oil, value 9d. in an argand, are equivalent in illuminating power to 3 pounds of tallow candles, which cost about two shillings. The larger the flame in the above candles, the greater the economy of light.

CANNEL COAL. See COAL.

CANNON METAL. See COPPER.

CANTHARIDES. Insects vulgarly called Spanish flies: lytta vesicatoria is the name adopted from Gmelin, by the London college. This insect is two-thirds of an inch in length, one-fourth in breadth, oblong, and of a gold shining colour, with soft elytera or wing sheaths, marked with three longitudinal raised stripes, and covering brown membranous wings. An insect of a square form, with black feet, but possessed of no vesicating property, is sometimes mixed with the cantharides. They have a heavy disagreeable odour, and acrid taste.

If the inspissated watery decoction of these insects be treated with pure alcohol, a solution of a resinous matter is obtained, which being separated by gentle evaporation to dryness, and submitted for some time to the action of sulphuric ether, forms a yellow solution. By spontaneous evaporation, crystalline plates are deposited, which may be freed from some adhering colouring matter by alcohol. Their appearance is like spermaceti. They are soluble in boiling alcohol, but precipitate as it cools. They do not dissolve in water. According to M. Robiquet, who first discovered them, these plates form the true blistering principle. They might be called VESICATORIN. Besides the above peculiar body, cantharides contain, according to M. Robiquet, a green bland oil, insoluble in water, soluble in alcohol; a black matter, soluble in water, insoluble in alcohol, without blistering properties; a yellow viscid matter, mild, soluble in water and alcohol; the crystalline plates; a fatty bland matter; phosphates of lime and magnesia; a little acetic acid, and much lithic or uric acid. The blistering fly taken into the stomach in doses of a few grains, acts as a poison, occasioning horrible satyriasis, delirium, convulsions, and death. Some frightful cases are related by Orfila, vol. i. part 2d. Oils, milk, syrups, frictions on the spine, with volatile liniment and laudanum, and draughts containing musk, opium, and camphoretted emulsion, are the best antidotes.

Cantharides consist, by my analysis, of 48.64 carbon + 5.99 hydrogen + 36.29 oxygen + 9.08 azote = 100. Their constitution approximates to

Carbon	11 atoms	9.75	11.4
Hydrogen	10	1.25	6.3
Oxygen	7	7.00	35.4
Azote	1	1 75	8.9
		19.75	100.0

CAOUTCHOUC. This substance, which has been improperly termed *elastic gum*, and vulgarly, from its common application to rub out pencil marks on paper, *India rubber*, is obtained from the milky juice of different plants in hot countries. The chief of these are the *Jatropha elastica*, and *Urceola elastica*.

The juice is applied in successive coatings on a mould of clay, and dried by the fire or in the sun; and when of a sufficient thickness, the mould is crushed, and the pieces shaken out. Acids separate the caoutchouc from the thinner part of the juice at once by coagulating it. The juice of old plants yields nearly two-thirds of its weight; that of younger plants less. Its colour, when fresh, is yellowish-white, but it grows darker by exposure to the air.

The elasticity of this substance is its most remarkable property: when warmed, as by immersion in hot water, slips of it may be drawn out to seven or eight times their original length, and will return to their former dimensions nearly. Cold renders it stiff and rigid, but warmth restores its original elasticity. Exposed to the fire it softens, swells up, and burns with a bright flame. In Cayenne it is used to give light as a candle. Its solvents are ether, volatile oils, and petroleum. The ether, however, requires to be washed with water repeatedly, and in this state it dissolves it completely. Pelletier recommends to boil the caoutchouc in water for an hour; then to cut it into slender threads; to boil it again about an hour; and then to put it into rectified sulphuric ether in a vessel close stopped. In this way he says it will be totally dissolved in a few days, without heat, except the impurities, which will fall to the bottom if ether enough be employed. Berniard says, the nitrous ether dissolves it better than the sulphuric. If this solution be spread on any substance, the ether evaporates very quickly, and leaves a coating of caoutchouc unaltered in its properties. Naphtha, or petroleum, rectified into a colourless liquid, dissolves it, and likewise leaves it unchanged by evaporation. Oil of turpentine softens it, and forms a pasty mass, that may be spread as a varnish, but is very long in drying. A solution of caoutchouc in five times its weight of oil of turpentine, and this solution dissolved in eight times its weight of drying linseed oil by boiling, is said to form the varnish of air-balloons. Alkalis act upon it so as in time to destroy its elasticity. Sulphuric acid is decomposed by it; sulphurous acid being evolved, and the caoutchouc converted into charcoal. Nitric acid acts upon it with heat; nitrous gas being given out, and oxalic acid crystallizing from the residuum. On distillation it gives out ammonia, and carburetted hydrogen.

By my analysis, Caoutchouc is composed in 100 parts of 90.00 carbon, 9.11 hydrogen, and 0.88 oxygen. It probably consists therefore of

Carbon	3 atoms	2.25	90
Hydrogen	2	0.25	10
		2.50	100

or it is a sesqui-carburetted hydrogen. The oxygen deduced from experiment is in such small quantity, as to leave a doubt whether it be essential to this body, or imbibed in minute quantity from the atmosphere during its consolidation.

Mr. Faraday has lately written an ingenious memoir on Caoutchouc. He obtained it from Mexico in the fluid state, nearly as it exudes from the tree. The only alteration was a slight film of solid caoutchouc on the surface of the cork which closed the bottle. The fluid was a pale-yellow, thick, cream-looking substance, of uniform consistency. It had a disagreeable acescent odour, something resembling that of putrescent milk; its sp. gr. was 1.01174. When exposed to the air in thin films it soon dried, losing weight, and leaving caoutchouc of the usual appearance and colour; and very tough and elastic. 202.4 gr. of the liquid dried in a Wedgewood basin, at 100° F., became in a few days 94.4 grains, and the solid piece formed being then removed from the capsule, and exposed on all sides to the air until quite dry, became 91 grains. Hence 100 parts of juice left nearly 45 of solid matter. Heat immediately coagulates the juice, the caoutchouc separating in its solid form from the aqueous matter. Alcohol has a similar effect. The juice mixes freely with water, but after some time a creamy portion rises to the top, while a clear watery solution of the matters associated with caoutchouc in the juice remains below. In this way liquid caoutchouc may be purified by washing. When this is thrown on a filter, the water passes through and leaves coagulated caoutchouc. This pure transparent substance has when dry a sp. gravity of 0.925. It is a non-conductor of electricity. It is not dissolved when boiled in solution of potash. "It yields no ammonia by destructive distillation, nor any compounds of oxygen, and my experiments agree with those of Dr. Ure, in indicating carbon and hydrogen as its only elements. I have not however been able to verify his proportions, which are 90 carbon, 9.11 hydrogen, or by theory nearly 3 proportionals of carbon to 2 of hydrogen, and have never obtained quite so much as 7 carbon to 1 hydrogen by weight." This difference in Mr. Faraday's results, I would ascribe to a difference in the nature of the caoutchouc; for it is certain that by my mode of ultimate analysis I can never have an error of carbon in excess. Mr. Faraday's mean results are 8 atoms of carbon + 1 of hydrogen, nearly. *Journal of Science*, xxi. 19.

Caoutchouc may be formed into various articles without undergoing the process of solution. If it be cut into an uniform slip of a proper thickness, and wound spirally round a glass or metal rod, so that the edges shall be in close contact, and in this state be boiled for some time, the edges will adhere so as to form a tube. Pieces of it may be readily joined by touching the edges with the solution in ether; but this is not absolutely necessary, for, if they be merely softened by heat, and then pressed together, they will unite very firmly.

If linseed oil be rendered very drying by digesting it upon an oxide of lead, and afterward applied with a small brush on any surface, and dried by the sun or in the smoke, it will afford a pellicle of considerable firmness, transparent, burning like caoutchouc, and wonderfully elastic. A pound of this oil, spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of caoutchouc: it was used to make catheters and bougies, to varnish balloons, and for other purposes.

Of the mineral caoutchouc there are several varieties: 1. Of a blackish-brown inclining to olive, soft, exceedingly compressible, unctuous, with a slightly aromatic smell. It burns with a bright flame, leaving a black oily residuum, which does not become dry. 2. Black, dry, and cracked on the surface, but, when cut into, of a yellowish-white. A fluid resembling pyrolignic acid exudes from it when recently cut. It is pellucid on the edges, and nearly of a hyacinthine red colour. 3. Similar to the preceding, but of a somewhat firmer texture, and ligneous appearance, from having acquired consistency in repeated layers. 4. Resembling the first variety, but of a darker colour, and adhering to grey calcareous spar, with some grains of galæna. 5. Of a liver-brown colour, having the aspect of the vegetable caoutchouc, but passing by gradual transition into a brittle bitumen, of vitreous lustre, and a yellowish colour. 6. Dull reddish-brown, of a spongy or cork-like texture, containing blackish-grey nuclei of impure caoutchouc. Many more varieties are enumerated.

One specimen of this caoutchouc has been found in a petrified marine shell enclosed in a rock, and another enclosed in crystallized fluor spar.

The mineral caoutchouc resists the action of solvents still more than the vegetable. The rectified oil of petroleum affects it most, particularly when by partial burning it is resolved into a pitchy viscous substance. A hundred grains of a specimen analyzed in the dry way by Klaproth afforded carburetted hydrogen gas 38 cubic inches, carbonic acid gas 4, bituminous oil 73 grains, acidulous phlegm 1.5, charcoal 6.25, lime 2, silex 1.5, oxide of iron .75, sulphate of lime .5, alumina .25.

CAPUT MORTUUM. The inert residuum of a distillation, or sublimation. The term is nearly obsolete.

CARAT. See ASSAY and DIAMOND.

CARBON. When vegetable matter, particularly the more solid, as wood, is exposed to heat in close vessels, the volatile parts fly off, and leave behind a black porous substance, which is charcoal. If this be suffered to undergo combustion in contact with oxygen, or with atmospheric air, much the greater part of it will combine with the oxygen, and escape in the form of gas; leaving about a two-hundredth part, which consists chiefly of different saline and metallic substances. This pure inflammable part of the charcoal is what is commonly called *carbon:* and if the gas be received into proper vessels, the carbon will be found to have been converted by the oxygen into an acid, called the carbonic. See ACID (CARBONIC).

From the circumstance that inflammable substances refract light in a ratio greater than that of their densities, Newton inferred that the diamond was inflammable. The quantity of the inflammable part of charcoal requisite to form a hundred parts of carbonic acid, was calculated by Lavoisier to be twenty-eight parts. From a careful experiment of Mr. Tennant, 27.6 parts of diamond, and 72.4 of oxygen, formed 100 of carbonic acid; and hence he inferred the identity of diamond and the inflammable part of charcoal.

Diamonds had been frequently consumed in the open air with burning-glasses; but Lavoisier first consumed them in oxygen gas, and discovered carbonic acid to be the only result. Sir George Mackenzie showed, that a red heat, inferior to what melts silver, is sufficient to burn diamonds. They first enlarge somewhat in volume, and then waste with a feeble flame. M. Guyton Morveau was the first who dropped diamonds into melted nitre, and observed the formation of carbonic acid.

From a number of experiments which M. Biot has made on the refraction of different substances, he has been led to form a different opinion. According to him, if the elements of which a substance is composed be known, their proportions may be calculated with the greatest accuracy from their refractive powers. Thus he finds, that the diamond cannot be pure carbon, but requires at least one-fourth of hydrogen, which has the greatest refractive power of any substance, to make its refraction commensurate to its density.

In 1809, Messrs. Allen and Pepys made some accurate researches on the combustion of various species of carbon in oxygen, by means of an elegant apparatus of their own contrivance. A platina tube traversing a furnace, and containing a given weight of the carbonaceous substance, was connected at the ends with two mercurial gasometers, one of which was filled with oxygen gas, and the other was empty. The same weight of diamond, carbon, and plumbago, yielded very nearly the same volume of carbonic acid. Sir H. Davy was the first to show that the diamond was capable of supporting its own combustion in oxygen, without the continued application of extraneous heat; and he thus obviated one of the apparent anomalies of this body, compared with charcoal. This phenomenon, by his method, can now be easily exhibited. If the diamond, supported in a perforated cup, be fixed at the end of a jet, so that a stream of hydrogen can be thrown on it, it is easy, by inflaming the jet, to ignite the gem, and whilst in that state to introduce it into a globe or flask containing oxygen. On turning off the hydrogen, the diamond enters into combustion, and will go on burning till nearly consumed. The loss of weight, and corresponding production of carbonic acid, were thus beautifully shown. A neat form of apparatus for this purpose is delineated by Mr. Faraday, in the 9th volume of the Journal of Science. Sir H. Davy found, that diamonds gave a volume of pure carbonic acid, equal to the oxygen consumed; charcoal and plumbago afforded a minute portion of hydrogen. See DIAMOND.

Well-burned charcoal is a conductor of electricity, though wood simply deprived of its moisture by baking is a non-conductor; but it is a very bad conductor of caloric, a property of considerable use on many occasions, as in lining crucibles.

It is insoluble in water, and hence the utility of charring the surface of wood exposed to that liquid, in order to preserve it, a circumstance not unknown to the ancients. This preparation of timber has been proposed as an effectual preventive of what is commonly called the dry-rot. It has an attraction, however, for a certain portion of water, which it retains very forcibly. Heated red-hot, or nearly so, it decomposes water; forming with its oxygen carbonic acid, or carbonic oxide, according to the quantity present; and with the hydrogen a gaseous carburet, called carburetted hydrogen, or heavy inflammable air.

Charcoal is infusible by any heat. If exposed to a very high temperature in close vessels, it loses little or nothing of its weight, but shrinks, becomes more compact, and acquires a deeper black colour.

Recently prepared charcoal has a remarkable property of absorbing different gases, and condensing them in its pores without any alteration of their properties or its own.

The following are the latest results of M. Theodore de Saussure with boxwood charcoal, the most powerful species:

Gaseous ammonia,	90 vols.
Ditto muriatic acid,	85
Ditto sulphurous acid,	65
Sulphuretted hydrogen,	55
Nitrous oxide,	40
Carbonic oxide,	35
Olefiant gas,	35
Carbonic oxide,	9.42
Oxygen,	9.25

Azote,	7·5 vols.
Light gas from moist charcoal,	5·0
Hydrogen,	1·75

Very light charcoal, such as that of cork, absorbs scarcely any air; while the pit-coal of Rastiberg, sp. gr. 1·326, absorbs $10\frac{1}{2}$ times its volume. The absorption was always completed in 24 hours. This curious faculty, which is common to all porous bodies, resembles the action of capillary tubes on liquids. When a piece of charcoal, charged with one gas, is transferred into another, it absorbs some of it, and parts with a portion of that first condensed. In the experiments of Messrs. Allen and Pepys, charcoal was found to imbibe from the atmosphere in a day about 1-8th of its weight of water. For a general view of absorption, see Gas.

When oxygen is condensed by charcoal, carbonic acid is observed to form at the end of several months. But the most remarkable property displayed by charcoals impregnated with gas, is that with sulphuretted hydrogen, when exposed to the air or oxygen gas. The sulphuretted hydrogen is speedily destroyed, and water and sulphur result, with the disengagement of considerable heat. Hydrogen alone has no such effects. When charcoal was exposed by Sir H. Davy to intense ignition *in vacuo*, and in condensed azote, by means of Mr. Children's magnificent voltaic battery, it slowly volatilized, and gave out a little hydrogen. The remaining part was always much harder than before; and in one case so hard as to scratch glass, while its lustre was increased. This fine experiment may be regarded as a near approach to the production of diamond.

Charcoal has a powerful affinity for oxygen, whence its use in disoxygenating metallic oxides, and restoring their base to its original metallic state, or reviving the metal. Thus too it decomposes several of the acids, as the phosphoric and sulphuric, from which it abstracts their oxygen, and leaves the phosphorus and sulphur free.

Carbon is capable of combining with sulphur, and with hydrogen. With iron it forms steel; and it unites with copper into a carburet, as observed by Dr. Priestley.

A singular and important property of charcoal is that of destroying the smell, colour, and taste of various substances: for the first accurate experiments on which we are chiefly indebted to Mr. Lowitz of Petersburgh, though it had been long before recommended to correct the fœtor of foul ulcers, and as an antiseptic. On this account it is certainly the best dentifrice. Water that has become putrid by long keeping in wooden casks, is rendered sweet by filtering through charcoal powder, or by agitation with it: particularly if a few drops of sulphuric acid be added. Common vinegar boiled with charcoal powder becomes perfectly limpid. Saline solutions, that are tinged yellow or brown, are rendered colourless in the same way, so as to afford perfectly white crystals. The impure carbonate of ammonia obtained from bones, is deprived both of its colour and fetid smell by sublimation with an equal weight of charcoal powder. Malt spirit is freed from its disagreeable flavour by distillation from charcoal; but if too much be used, part of the spirit is decomposed. Simple maceration, for eight or ten days, in the proportion of about 1-150th of the weight of the spirit, improves the flavour much. It is necessary that the charcoal be well burned, brought to a red heat before it is used, and used as soon as may be, or at least be carefully excluded from the air. The proper proportion too should be ascertained by experiment on a small scale. The charcoal may be used repeatedly, by exposing it for some time to a red heat before it is again employed.

Charcoal is used on particular occasions as fuel, on account of its giving a strong and steady heat without smoke. It is employed to convert iron into steel by cementation. It enters into the composition of gunpowder. In its finer states, as in ivory black, lamp black, &c. it forms the basis of black paints, Indian ink, and printers' ink.

The purest carbon for chemical purposes is obtained by strongly igniting lamp black in a covered crucible. This yields, like the diamond, unmixed carbonic acid by combustion in oxygen.

Carbon unites with all the common simple combustibles, and with azote, forming a series of most important compounds. With sulphur it forms a curious limpid liquid called carburet of sulphur, or sulphuret of carbon. With phosphorus it forms a species of compound, whose properties are imperfectly ascertained. It unites with hydrogen in two definite proportions, constituting subcarburetted and carburetted hydrogen gases. With azote it forms prussic gas, the cyanogen of M. Gay Lussac. Steel and plumbago are two different compounds of carbon with iron. In black chalk we find this combustible intimately associated with silica and alumina. The primitive combining proportion, or prime equivalent of carbon, is 0.75 on the oxygen scale.

CARBON (MINERAL), is of a greyish-black colour. It is charcoal, with various proportions of earth and iron, without bitumen. It has a silky lustre, and the fibrous texture of wood. It is found in small quantities, stratified with brown coal, slate coal, and pitch coal.

CARBON (Chlorides of). For the knowledge of this interesting class of compounds, we are indebted to Mr. Faraday.

If chlorine and olefiant gas be mixed in equal volumes, they are condensed into an oily looking liquid, sometimes called chloric ether. (See Carburetted Hydrogen.) If some of this be put into a retort with chlorine, it becomes yellow; but on exposure to the sunbeams, heat is produced, and the colour of the gas and liquid disappears in a few seconds. On opening the retort under mercury, there is no absorption. It is found to be now full of muriatic acid gas. If we expel this, introduce more chlorine, and again expose to the sun light, the colour which had been regenerated again disappears, while a few moist crystals form round the edge of the fluid. Chlorine being a third time introduced, and subjected to the same influence, more hydrogen is withdrawn from the liquid, and a crystalline sublimate lines the retort. By proceeding in this way, till the chlorine exerts no farther action, the fluid entirely vanishes, and leaves in its stead the crystalline matter and muriatic acid.

Mr. Faraday next added at once to a portion of olefiant gas eight or nine times its bulk of chlorine, and exposed the mixture to sunshine. At first the fluid formed; but it speedily disappeared; the retort became lined with crystals, and the colour of the chlorine grew paler. These crystals are a chloride of carbon. As water does not interfere with the action of the substances, Mr. Faraday admitted a little of it, which condensed the muriatic acid gas, and allowed a new volume of chlorine to be introduced into the retort to de-hydrogenate the chloric ether, by the aid of light. In order to insulate the substance, the residuary chlorine and muriatic acid gas were blown out of the vessel with a pair of bellows; and the condensed muriatic acid gas, and other soluble matters, were washed away with water. The crystalline substance is to be now washed from the retort into another jar. A little alcohol will remove the last adhering portions. This being poured into the water, will throw down the chloride to the bottom of the vessel. It ought to be next dried by pressure between the folds of porous paper. It is then to be sublimed in a glass tube, by the heat of a spirit lamp. The pure substance will rise first along with a little water; but the last portions will be partially decomposed, muriatic acid being evolved, while charcoal remains. The sublimed matter is to be dissolved in alcohol, and the solution is to be poured into a weak potash ley, by which the chloride is thrown down, and the muriatic acid neutralized and separated. Water will now wash away the muriatic acid and muriate, leaving the substance pure. Collect it on a filter, and dry it, first between the folds of blotting paper, and lastly, over sulphuric acid, in the exhausted receiver.

It will now appear as a white pulverulent substance; and, if perfectly pure, will not afford the slightest trace of carbon, or muriatic acid, when sublimed in a tube. Its solution in ether should not affect solution of nitrate of silver. If it does, it must be resublimed, washed, and dried.

For the formation of this substance, the direct rays of the sun are not absolutely necessary. The light of day, acting for a few hours, will determine its production. It will form even in the dark, at the end of a few days.

The solid thus obtained is the *perchloride.* It is transparent and colourless. It has scarcely any taste. Its odour is aromatic, approaching to that of camphor. Its specific gravity is as nearly as possible 2. In refractive power, it equals flint glass (1.5767). It is very fusible, easily breaking down under pressure; and, when scratched, has much of the feel and appearance of white sugar. It does not conduct electricity.

The crystals obtained by sublimation, as well as from solutions of the substance in alcohol and ether, are dendritical, prismatic, or in plates. The varieties of form, which are very interesting, are easily ascertained, and result from a primitive octohedron.

It volatilizes slowly at common temperatures, and passes, in the manner of camphor, towards the light. If heated, it rises more rapidly, forming fine crystals. When the temperature is raised to 320° F. it fuses; and to 360° it boils. When condensed from these rapid sublimations, it forms a transparent and scarcely visible crust; which, soon after it cools, becomes white and nearly opaque. If the heat be raised still higher, as when the substance is passed through a red-hot tube, it is decomposed, chlorine is evolved, and another chloride of carbon, which condenses into a liquid, is obtained. This shall be described presently.

It is not readily combustible. When held in the flame of a spirit lamp, it burns with a red flame, emitting much smoke and acid fumes; but on removal from the lamp, its combustion ceases. When it is heated to redness in pure oxygen, it sometimes burns with a brilliant light.

It is insoluble in water, but soluble in alcohol, and copiously with the aid of heat. It is still more soluble in ether. The hot ethereous solution deposits, on cooling, very beautiful crystals. It is soluble also in the volatile oils; from which it may be obtained in crystals by evaporation. Fixed oils likewise dissolve it.

Solutions of the acids and alkalis do not act with any energy on this chloride.

When oxygen, mixed with its vapour, is passed through a red-hot tube, there is decomposition; and mixtures of chlorine, carbonic oxide, carbonic acid, and phosgene gases are obtained.

Chlorine produces no change on this substance. When iodine is heated with it at moderate temperatures, the two substances unite with fusion, and there is no further action. When heated more strongly in vapour of iodine, the iodine separates chlorine, reducing the perchloride to the fluid protochloride of carbon, while chloriodine is formed.

This dissolves, and if no excess of iodine be present, the whole remains fluid at common temperatures. When water is added, it generally liberates a little iodine; and on heating the solution so as to expel all free iodine, and testing by nitrate of silver, chloride and iodide of silver are obtained.

When a mixture of hydrogen and vapour of the perchloride is transmitted through a red-hot tube, the latter is decomposed with the production of muriatic acid gas and charcoal. Sulphur and phosphorus unite to it by fusion. If phosphorus be heated in the vapour of this chloride, it abstracts chlorine, whence result protochloride of phosphorus and carbon. If heated more highly, it inflames.

Most of the metals decompose it at high temperatures. Potassium burns brilliantly in the vapour; when a chloride of potassium is formed, and charcoal deposited. Iron, zinc, tin, copper, and mercury, act on it at a red heat, forming chlorides of these metals, with deposition of the charcoal. The peroxides of mercury, copper, lead, and tin, heated with the perchloride, produce chlorides of the respective metals and carbonic acid; and the protoxides of zinc, lead, &c. produce also chlorides; but the gaseous product is a mixture of carbonic acid and carbonic oxide. Phosgene gas is occasionally formed on passing the perchloride over heated oxide of zinc.

When the vapour of the chloride is passed over red-hot lime, barytes, or strontites, a very vivid combustion is produced. The oxygen and the chlorine change places. The combustion is due to the formation of the earthy chlorides, and carbonic acid; the last being absorbed by the undecomposed portions of the earths. Carbon is also deposited. No carbonic oxide is obtained. When the substance is passed over ignited magnesia, there is no action on the earth; but the perchloride of carbon is converted by the heat into a protochloride. In these experiments with the oxides, no trace of water could be perceived. The most perfect demonstration of the new body containing no hydrogen, is evident from this, that when the fluid compound of chlorine and olefiant gas is acted on by chlorine and the sunbeams in close vessels, there is no change of volume, though the whole of the chlorine disappears; its place being occupied by muriatic acid gas. Hence, as muriatic acid gas is known to consist of equal volumes of chlorine and hydrogen, combined without change of bulk, it is evident that half of the chlorine introduced into the vessel is fixed in the elements of the liquid, and has liberated an equal volume of hydrogen; and as, when the chloride is perfectly formed, it condenses no muriatic acid gas, a method, apparently free from all fallacy, is thus afforded of ascertaining its nature.

By a train of well-conducted experiments, Mr. Faraday ascertained, that 1 volume of olefiant gas requires 5 volumes of chlorine for its conversion into muriatic acid and chloride of carbon; that 4 volumes of muriatic acid gas are formed; that 3 volumes of chlorine combine with the 2 volumes of carbon in the olefiant gas to form the solid crystalline chloride; and that when chlorine acts on the fluid compound of chlorine and olefiant gas, for every volume of chlorine that combines, an equal volume of hydrogen is separated.

He verified these proportions by analysis, transmitting the substance in vapour slowly over metals and metallic oxides, (chiefly peroxide of copper.)

The composition of the perchloride of carbon is,

3 prime proportions of chlorine,
2 carbon.

Mr. Faraday's numbers are 100.5 + 11.4. According to the numbers adopted in this work, they are 13.5 + 1.5, or in 100 parts, 90 chlorine + 10 carbon.

2. *Protochloride of carbon.* By heating some of the perchloride in a glass tube, over a spirit lamp, the substance at first sublimes; but as the vapour becomes heated below, it is gradually converted into protochloride, while chlorine is disengaged. To obtain it pure, he passes some of the perchloride to the sealed end of a tube, and fills the space above it for 10 or 12 inches with fragments of rock-crystal. The part of the tube beyond this is bent zigzag 2 or 3 times, so that the angles may form receivers for the new body. These angles being plunged in cool water, he heats the tube and rock-crystal to bright redness; after which the perchloride is slowly sublimed by a spirit lamp; and on passing into the hot part of the tube is decomposed. A fluid passes over, which is condensed in the angles of the tube, and chlorine is separated; part of the gas escapes, but the greater portion is retained in solution by the fluid, and renders it yellow. Having proceeded thus far, we may then separate the bent portion of the tube from that within the furnace, by the skilful use of the blowpipe, which will seal the end of the tube. This now forms a retort; in which we may chase the fluid by heat, from one end to another, four or five times; whereby the excess of chlorine will be expelled, and the chloride obtained limpid and colourless. The small proportion of perchloride which still remains, is separable by another distillation *in vacuo*, at a heat little above that of the atmosphere; the protochloride being the more volatile body, and evaporating speedily in the air without leaving any residuum.

The pure protochloride is a highly limpid fluid, and perfectly colourless. Its specific gravity is 1.5526. It is a non-conductor of electricity. By Dr. Wollaston's determination its refractive power is 1.4875, being very nearly that of camphor. It is not combustible, except when held in a flame, as of a spirit lamp; and then it burns with a bright yellow light, much smoke, and fumes of muriatic acid. It does not become solid at the zero of Fahrenheit's scale. When its temperature is raised under the surface of water to between 160° and 170° F. it is converted into vapour, and remains in that state until the temperature is lowered. It is insoluble in water; but it dissolves readily, in alcohol and ether, the fixed and volatile oils. It is not soluble in alkaline or acid solutions.

At a high temperature oxygen decomposes it, forming carbonic oxide or acid, with disengagement of chlorine.

Chlorine converts it into the perchloride.

With iodine it forms a brilliant red solution.

When hydrogen and the vapour of the protochloride are passed through a red-hot tube, there is a complete decomposition. Muriatic acid gas is formed, and charcoal is deposited. The mixed vapour and the gas burn with flame as they arrive in the hot part of the tube.

Sulphur and phosphorus dissolve in it; and the latter decomposes it at a red heat. Its action on metals and metallic oxides is very similar to that of the perchloride. By an analysis conducted in the same way as that of the perchloride, Mr. Faraday ascertained that this liquid chloride is composed of 1 prime proportion of chlorine, and 1 of carbon, or by weight,

Chlorine,	-	4.5
Carbon,	-	0.75

3. *Subchloride of carbon.* This compound was brought to England, and given to Mr. Richard Phillips and Mr. Faraday by M. Julin of Abo, in Finland, having been formed during the distillation of green vitriol and nitre for the production of nitric acid. It is a solid crystalline body, fusible and volatile by heat without decomposition, and condensing into crystals. It is insoluble in water; but soluble in alcohol, ether, and essential oils. It sinks in water. It burns with a red flame, giving off much smoke, and fumes of muriatic acid gas. Acids do not act on it. When its vapour is highly heated in a tube, decomposition takes place, chlorine is given off, and charcoal deposited. Potassium burnt with it forms chloride of potassium, and liberates charcoal. Its vapour, detonated with oxygen over mercury, formed carbonic acid and chloride of mercury; passed over hot oxide of copper, it formed a chloride of copper and carbonic acid; and over hot lime, it occasioned ignition, and produced chloride of calcium, and carbonic acid. It is formed of

1 prime proportion of chlorine,
and 2 of carbon.

In numbers, of chlorine,	4.5 —	75
carbon,	1.5	25
		100

All attempts to form it by other means have failed.

We are also indebted to Mr. Faraday for a triple compound of iodine, carbon, and hydrogen.

When iodine and olefiant gas are exposed together in a retort to the sunbeams, there are formed, after some time, colourless crystals, and a partial vacuum is produced. The residuary elastic fluid is olefiant gas. The free iodine is removed by a solution of potash, when the new compound is obtained pure. It is a solid, white, crystalline body, with a sweet taste, and aromatic smell. It sinks readily in sulphuric acid of 1.85. It is friable; and is a non-conductor of electricity. When heated, it first fuses, and then sublimes without any change. Its vapour condenses into crystals, which are either prisms or plates. On becoming solid after fusion, it also crystallises in plates. The crystals are transparent. At a high heat it is decomposed, and iodine evolved. It is not readily combustible. It is insoluble in water, and in alkaline and acid solutions; but it is soluble in alcohol and ether; from which solutions it may be obtained by evaporation in crystals.

CARBONATES. Compounds of carbonic acid with the salifiable bases. They are composed either of one prime of the acid and one of the base, or of two of the acid and one of the base. The former set of compounds is called carbonates, the latter bicarbonates. See CARBONIC ACID.

As the system of chemical equivalents, or atomic theory of chemical combination, derives some of its fundamental or prime proportions from the constitution of the carbonates, their analysis requires peculiar precautions. In the Annals of Philosophy for October, 1817, I gave a description of a new instrument for accomplishing this purpose with the minutest precision.

The usual mode of analysis is to put a given weight of the carbonate in a phial, and add to it a certain quantity of a liquid acid, which will dissolve the base, and disengage the carbonic acid. I found, with every care I could take in this method, that variable and uncertain quantities of the liquid acid were apt to be carried off in vapour with the carbonic gas, while a portion of this gaseous acid was generally retained in the saline liquid. Hence, in the analysis of crystallized carbonate of lime, the most uniform of all compounds, we have the following discordant results, which are of importance in the doctrine of equivalents:—

Mr. Kirwan makes it consist of

	45	acid + 55 lime,
MM. Aiken,	44	+ 56
Dr. Marcet,	43.9	+ 56.1
Dr. Wollaston,	43.7	+ 56.3
M. Vauquelin,	43.5	+ 56.5
M. Thenard,	43.28	+ 56.72
Dr. Thomson,	43.137	+ 56.863

If we deduce the equivalent of lime from the analysis of Dr. Marcet, so well known for his philosophical accuracy, we shall have, lime = 35.1 to carbonic acid 27.5.

I adduced the following experiments, selected from among many others, as capable of throwing light on the cause of these variations: "Into a small pear-shaped vessel of glass, with a long neck, and furnished with a hollow spherical stopper, drawn out, above and below, into a tube almost capillary, some dilute muriatic acid was put. The whole being poised in a delicate balance, 100 grains of calc spar in rhomboidal fragments were introduced, and the stopper was quickly inserted. A little while after the solution was completed, the diminution of weight, indicating the loss of carbonic acid, was found to be 42.2 grains. Withdrawing the stopper, inclining the vessel to one side for a few minutes, to allow the dense gas to flow out, the diminution became 43.3. Finally, on heating the body of the vessel to about 70°, while the hollow stopper was kept cool, small bubbles of gas escaped from the liquid, and the loss of weight was found to be 43.65, at which point it was stationary. This is a tedious process." The instrument which I subsequently employed is quick in its operation, and still more accurate in its results. It consists of a glass tube of the same strength and diameter with that usually employed for barometers, having a strong egg-shaped bulb, about 2 inches long, and 1¼ wide, blown at one of its ends, while the other is open and recurved like a syphon. The straight part of the tube, between the ball and bend, is about 7 inches long. The capacity, exclusive of the curved part, is a little more than 5 cubic inches. It is accurately graduated into cubic inches and hundredth parts, by the successive additions of equal weights of quicksilver, from a *measure* thermometric tube. Seven troy ounces and 66 grains of quicksilver occupy the bulk of one cubic inch. Four and a half such portions being introduced will fill the ball, and the beginning of the stem. The point in the tube, which is a tangent to the surface of the mercury, is marked with a file or a diamond. Then 34¼ grains, equal in volume to 1-100th of a cubic inch, being drawn up into the thermometric tube, rest at a certain height, which is also marked. The same measure of mercury is successively introduced and marked off, till the tube is filled.

"In the instrument thus finished, 1-200th of a cubic inch occupies on the stem about 1-14 of an inch, a space very distinguishable. The weight of carbonic acid equivalent to that number, is less than 1-400th of a grain. The mode of using it is perfectly simple and commodious, and the analytical result is commonly obtained in a few minutes."

For example, five grains of calcareous spar in three or four rhomboids were weighed with great care in a balance by Creighton, which turns with $\frac{1}{100000}$ of the weight in the scales. These are introduced into the empty tube, and made to slide gently along into the spheroid. The instrument is then held in nearly a horizontal position with the left hand, the top of the spheroid resting against the breast, with a small funnel bent at its point, inserted into the orifice of the tube. Quicksilver is now poured in till it be filled, which in this position is accomplished in a few seconds. Should any particles of air be entangled among the mercury, they are discharged by inverting the instrument, having closed the orifice with the finger. On reverting it, and tapping the ball with the finger, the fragments of spar rise to the top. Three or four hundredth parts of a cubic inch of mercury being displaced from the mouth of the tube, that bulk of dilute muriatic acid is poured in; then pressing the forefinger on the orifice, and inclining the instrument forwards, the acid is made to rise through the quicksilver. This, as it is displaced by the cooled carbonic acid, falls into a stone-ware or glass basin, within which the instrument stands in a wooden frame. When the solution is completed, the apparent volume of gas is noted, the mercury in the two legs of the syphon is brought to a level, or the difference of height above the mercury in the basin is observed, as also the temperature of the apartment, and the height of the barometer. Then the ordinary corrections being made, we have the exact volume of carbonic acid contained in five grains of calc spar. In very numerous experiments, which I have made in very different circumstances of atmospherical pressure and temperature, the results have not varied one-hundredth of a cubic inch, on five grains, care being had to screen the instrument from the radiation of the sun or a fire.

As there is absolutely no action exercised on mercury by dilute muriatic acid at ordinary temperatures; as no perceptible difference is made in the bulk of air, by introducing to it over the mercury a little of the acid by itself; and as we can expel every atom of carbonic acid from the muriate of lime, or other saline solution, by gently heating that point of the tube which contains it, it is evident that the total volume of gaseous product must be accurately determined. When a series of experiments is to be performed in a short space of time, I wash the quicksilver with water, dry it with a sponge first, and then with warm muslin. The tube is also washed out and drained. According to my experiments with the above instrument, 5 grains of calcareous spar yield 4.7 cubic inches of carbonic acid, equivalent to 43.616 per cent. The difference between this number and Dr. Wollaston's is inconsiderable.

Among other results which I obtained from the use of the above instrument, it enabled me to ascertain the true composition of the sublimed carbonate of ammonia, which chemists had previously mistaken. I showed in the

Annals of Philosophy for September, 1817, that this salt contained 54.5 of carbonic acid, 30.5 ammonia, and 15 water, in 100 parts; numbers which, being translated into the language of equivalents, approach to the following proportions:—

Carbonic acid,	3 primes,	8.25	55.89
Ammonia,	2	4.26	28.86
Water,	2	2.25	15.25
		14.76	100.00

As this volatile salt possesses the curious property of passing readily from one system of definite proportions to another, absolute accordance between experiment and theory cannot be expected. The other salt gave for its constituents, 54.5 carbonic acid + 22.8 ammonia + 22.75 water = 100. Now, if these numbers be referred to Dr. Wollaston's oxygen scale, we shall have,—

			Theory.	Expt.
2	primes carbonic acid,	5.50	55.66	54.50
1	ammonia,	2.13	21.56	22.80
2	water,	2.25	22.78	22.75

These near approximations to the equivalent ratios, in compounds of a variable nature, do not seem to have attracted notice at the time. In the 14th Number of the Journal of Science, Mr. Phillips, whose attention to minute accuracy is well known, has published an ingenious paper on the subject, which begins with the following handsome acknowledgment of my labours: "During some late researches, my attention being directed to the composition of the carbonates of ammonia, I began, and had nearly completed an examination of them, before I observed that they had been recently analyzed by Dr. Ure; and I consider his results to be so nearly accurate, that I should have suppressed mine, if I had not noticed some circumstances respecting the compounds in question, which have, I believe, hitherto escaped observation."

Mr. Phillips's communication is valuable. It presents a luminous systematic view of the carbonates of ammonia and soda.

The indications of the above analytical instrument are so minute, as to enable us, by the help of the old and well-known theorem for computing the proportions of two metals from the specific gravity of an alloy, to deduce the proportions of the bases from the volume of gas disengaged by a given weight of a mixed carbonate. A chemical problem of this nature was practically solved by me, in presence of two distinguished Professors of the University of Dublin, in May 1816. But such an application is more curious than useful, since a slight variation in the quantity of gas, as well as accidental admixtures of other substances, are apt to occasion considerable errors. It determines, however, the nature and value of a limestone with sufficient practical precision. As 100 grains of magnesian limestone yield 99 cubic inches of gas, a convenient rule for it is formed when we say, that 10 grains will yield 10 cubic inches. In the same way, marles and common limestones may be examined, by subjecting a certain number of grains, in a graduated syphon tube, to the action of a little muriatic acid over mercury. *From the bulk of evolved gas, expressed in cubic inches and tenths, deduct 1-20th, the remainder will express the proportion of real limestone present in the grains employed.*

CARBONATE OF BARYTES. See WITHERITE.

CARBONATE OF LIME. See CALCAREOUS SPAR.

CARBONATE OF STRONTIAN. See STRONTIAN and HEAVY SPAR.

CARBONIC ACID. See ACID (CARBONIC).

CARBONIC OXIDE. A gaseous compound of one prime equivalent of carbon, and one of oxygen, consisting by weight of 0.75 of the former, and 1.00 of the latter. Hence the prime of the compound is 1.75, the same as that of azote. This gas cannot be formed by the chemist by the direct combination of its constituents; for at the temperature requisite for effecting an union, the carbon attracts its full dose of oxygen, and thus generates carbonic acid. It may be procured by exposing charcoal to a long-continued heat. The last products consist chiefly of carbonic oxide.

To obtain it pure, however, our only plan is to abstract one proportion of oxygen from carbonic acid, either in its gaseous state, or as condensed in the carbonates. Thus by introducing well calcined charcoal into a tube traversing a furnace, as is represented Plate I. fig. 2.; and when it is heated to redness, passing over it backwards and forwards, by means of two attached mercurial gasometers or bladders, a slow current of carbonic acid, we convert the acid into an oxide more bulky than itself. Each prime of the carbon becomes now associated with only one of oxygen, instead of two, as before. The carbon acting here by its superior mass, is enabled to effect the thorough saturation of the oxygen.

M. Dumas has proposed a new method of procuring carbonic oxide. He mixes salt of wood-sorrel (superoxalate of potash) with 5 or 6 times its weight of sulphuric acid, in a retort, and causing the mixture to boil, obtains a considerable quantity of a gas, composed of equal parts of carbonic acid, and carbonic oxide. Absorbing the acid by caustic potash, or lime, he has pure carbonic oxide. This method may be successfully employed to examine the salt of wood-sorrel of commerce. Supertartrate of potash treated in the same way would afford oxide of carbon, sulphurous acid, carbonic acid, and the liquid would become eventually black, in consequence of the evolution of charcoal. Pure superoxalate of potash, on the contrary, never gives out sulphurous acid; and the sulphuric acid employed remains perfectly limpid and colourless.

If we subject to a strong heat, in a gun barrel or retort, a mixture of any dry earthy carbonate, such as chalk, or carbonate of strontites, with metallic filings or charcoal, the combined acid is resolved as before into the gaseous oxide of carbon. The most convenient mixture is equal parts of dried chalk and iron, or zinc filings. By passing a numerous succession of electric explosions through one volume of carbonic acid, confined over mercury, two volumes of carbonic oxide, and one of oxygen, are formed, according to Sir H. Davy.

The specific gravity of this gas is stated by Gay Lussac and Thenard, from theoretical considerations, to be 0.96782, though Mr. Cruickshank's experimental estimate was 0.9569. As the gas is formed by withdrawing from a volume of carbonic acid half a volume of oxygen, while the bulk of the gas remains unchanged, we obtain its specific gravity by subtracting from that of carbonic acid half the specific gravity of oxygen. Hence $1.5277 - 0.5555 = 0.9722$, differing slightly from the above, in consequence of the French chemists rating the specific gravity of the two original gases at 1.51961 and 1.10359. Hence 100 cubic inches weigh $29\frac{5}{8}$ grains at mean pressure and temperature.

This gas burns with a dark blue flame. Sir H. Davy has shown, that though carbonic oxide in its combustion produces less heat than other inflammable gases, it may be kindled at a much lower temperature. It inflames in the atmosphere, when brought into contact with an iron wire heated to dull redness, whereas carburetted hydrogen is not inflammable by a similar wire, unless it is heated to whiteness, so as to burn with sparks. It requires, for its combustion, half its volume of oxygen gas, producing one volume of carbonic acid. It is not decomposable by any of the simple combustibles, except potassium and sodium. When potassium is heated in a portion of the gas, potash is formed with the precipitation of charcoal, and the disengagement of heat and light. Perhaps iron, at a high temperature, would condense the oxygen and carbon by its strong affinity for these substances. Water condenses $\frac{1}{50}$ of its bulk of the gas. The above processes are those usually prescribed in our systematic works, for procuring the oxide of carbon. In some of them a portion of carbonic acid is evolved, which may be withdrawn by washing the gaseous product with weak solution of potash, or milk of lime. We avoid the chance of this impurity by extricating the gas from a mixture of dry carbonate of barytes and iron filings, or of oxide of zinc, and previously calcined charcoal. The gaseous product, from the first mixture, is pure oxide of carbon. Oxide of iron, and pure barytes, remain in the retort. Carbonic oxide, when respired, is fatal to animal life. Sir H. Davy took three inspirations of it, mixed with about one-fourth of common air; the effect was a temporary loss of sensation, which was succeeded by giddiness, sickness, acute pains in different parts of the body, and extreme debility. Some days elapsed before he entirely recovered. Since then, Mr. Witter of Dublin was struck down in an apoplectic condition, by breathing this gas; but he was speedily restored by the inhalation of oxygen. See an interesting account of this experiment, by Mr. Witter, in the Phil. Mag. vol. 43.

When a mixture of it and chlorine is exposed to sunshine, a curious compound, discovered by Dr. John Davy, is formed, to which he gave the name of phosgene gas. I shall describe its properties in treating of chlorine. It has been called chlorocarbonic acid, though chlorocarbonous acid seems a more appropriate name.

CARBUNCLE, a gem highly prized by the ancients, probably the *alamandine*, a variety of noble garnet.

CARBURET OF SULPHUR. Called also sulphuret of carbon, and alcohol of sulphur.

This interesting liquid was originally obtained by Lampadius in distilling a mixture of pulverized pyrites and charcoal in an earthen retort, and was considered by him as a peculiar compound of sulphur and hydrogen. But MM. Clement and Desormes, with the precision and ingenuity which distinguish all their researches, first ascertained its true constitution to be carburetted sulphur; and they invented a process of great simplicity, for at once preparing it, and proving its nature. Thoroughly calcined charcoal is to be put into a porcelain tube, that traverses a furnace at a slight angle of inclination. To the higher end of the tube, a retort of glass, containing sulphur, is luted; and to the lower end is attached an adopter tube, which enters into a bottle with two tubulures, half full of water, and surrounded with very cold water or ice. From the other aperture of the bottle, a bent tube proceeds into the pneumatic trough. When the porcelain tube is brought into a state of ignition, heat is applied to the sulphur, which subliming into the tube, combines with the charcoal, forming the liquid carburet. The conclusive demonstration of such an experiment was however questioned by M. Berthollet, jun. and Cluzel. But MM. Berthollet, Thenard, and Vauquelin, the reporters on M. Cluzel's memoir, having made some experiments of their own upon the subject, concluded that the liquid in question was a compound of sulphur and carbon only.

Finally, an excellent paper was written on the carburet by M. Berzelius and Dr. Marcet, who confirmed the results of MM. Clement and Desormes, and added likewise several important facts.

If about ten parts of well calcined charcoal in powder, mixed with fifty parts of pulverised native pyrites (bisulphuret of iron), be distilled from an earthen retort, into a tubulated receiver surrounded with ice, more than one part of sulphuret of carbon may be obtained. If we employ the elegant process of M. Clement, we must take care that the charcoal be perfectly calcined, otherwise no carbonate will be obtained. In their early experiments, they attached to the higher end of the porcelain tube a glass one, containing the sulphur in small pieces, and pushed these successively forwards by a wire passing air-tight through a cork, at the upper end of the tube.

Besides the liquid carburet there is formed some carburetted and sulphuretted hydrogen, and a reddish-brown solid and very combustible matter, which seems to be sulphur slightly carburetted. This substance remains almost entirely in the adopter tube. The liquid carburet occupies the bottom of the receiver bottle, and may be separated from the supernatant water, by putting the whole into a funnel, whose tube is closed with the finger, and letting the denser brown carburet flow out below, whenever the distinction of the liquid into two strata is complete. Thus obtained, the carburet is always yellowish, containing a small excess of sulphur, which may be removed by distillation from a glass retort, plunged in water, at a temperature of 115°. It is now transparent and colourless, of a penetrating, fetid smell, and an acrid burning taste. Its specific gravity varies from 1·263 to 1·272. According to Dr. Marcet, it boils below 110°; according to M. Thenard, at 113° F.; and the tension of its vapour at 72·5° is equivalent to a column of 12·53 inches of mercury. At 53·5°, according to Marcet and Berzelius, the tension is equivalent to a column of 7·4 inches, or one-fourth of the mean atmospheric pressure; hence one-third is added to the bulk of any portion of air, with which the liquid may be mixed. A spirit of wine thermometer, having its bulb surrounded with cotton cloth or lint, if dipped in sulphuret of carbon, and suspended in the air, sinks from 60° to 0°. If it be put into the receiver of an air-pump, and a moderate exhaustion be made, it sinks rapidly from 60° to — 81°. If a tube containing mercury be treated in the same way, the mercury may be readily frozen even in summer. The drier the air in the receiver, the more easily is the cold produced. Hence the presence of sulphuric acid may be of some service in removing the vapour from the air in the receiver.

This carburet may be cooled to — 80° without congealing; a conclusive proof that combination changes completely the constitution of bodies, since two substances usually solid form a fluid which we cannot solidify. When a lighted body approaches the surface of the carburet, it immediately catches fire, and burns with a blue sulphurous flame. Carbonic and sulphurous acids are exhaled, and a little sulphur is deposited. A heat of about 700° inflames the vapour of the carburet. Oxygen dilated by it over mercury exploded by the electric spark, with a violent detonation. My eudiometer is peculiarly adapted to the exhibition of this experiment. A portion of oxygen being introduced into the sealed leg, we pour a few drops of the carburet on the surface of the mercury in the open leg, and closing this with the finger, transfer the liquid to the other by a momentary inclination of the syphon. The expansion of volume can be now most accurately measured by bringing the mercury to a level in each leg.

The subsequent explosion occasions no danger, and a scarcely audible report. The result is a true analysis, if we have mixed oxygen saturated with the vapour, at ordinary pressure and temperature, with about its volume of pure oxygen; otherwise, all the sulphur would not be oxygenated. We obtain, then, sulphurous and carbonic acids, with the excess of oxygen.

The carburet of sulphur dissolves camphor. It does not unite with water; but very readily with alcohol and ether. With chloride of azote it forms a non-detonating compound. The waters of potash, barytes, and lime, slowly decompose it, with the evolution of carbonic acid gas. It combines with ammonia and lime, forming carbo-sulphurets. The carburet, saturated with ammoniacal gas, forms a yellow pulverulent substance, which sublimes unaltered in close vessels, but is so deliquescent that it cannot be passed from one vessel to another without absorbing moisture. When heated in that state, crystals of hydrosulphuret of ammonia form. The compound with lime is made by heating some quicklime in a tube, and causing the vapour of carburet to pass through it. The lime becomes incandescent at the instant of combination.

When the carburet is left for some weeks in contact with nitro-muriatic acid, it is converted into a substance having very much the appearance and physical properties of camphor; being soluble in alcohol and oils, and insoluble in water. This substance is, according to Berzelius, a triple acid, composed of two atoms of muriatic acid, one atom of sulphurous acid, and one atom of carbonic acid. He calls it, muriatico-sulphurous-carbonic acid.

When potassium is heated in the vapour of the carburet, it burns with a reddish flame, and a black film appears on the surface. On admitting water, a greenish solution of sulphuret of potash is obtained, containing a mixture of charcoal. From its vapour passing through ignited muriate of silver, without occasioning any reduction of the metal, it is demonstrated that this carburet is destitute of hydrogen.

When the compound of potash, water, and carburet of sulphur, is added to metallic solutions, precipitates of a peculiar kind, called carbo-sulphurets, are obtained. The following is a table of the colours of the precipitates:—

Muriate of cerium,	White or yellowish-white.
Sulphate of manganese,	Greenish-grey.
Sulphate of zinc,	White.
Permuriate of iron,	Dark red.
Submuriate of antimony,	Orange.
Muriate of tin,	Pale orange, then brown.
Nitrate of cobalt,	Dark olive-green, at last black.
Nitrate of lead,	A fine scarlet.
Nitrate of copper,	Dark brown.
Protomuriate of mercury,	Black.
Permuriate of mercury,	Orange.
Muriate of silver,	Reddish-brown.

Carburet of sulphur was found by Dr. Brewster to exceed all fluid bodies in refractive power, and even the solids, flint-glass, topaz, and tourmaline. In dispersive power it exceeds every fluid substance except oil of cassia, holding an intermediate place between phosphorus and balsam of Tolu.

The best method of analyzing the carburet of sulphur is to pass its vapour over ignited peroxide of iron; though the analysis was skilfully effected by MM. Berthollet, Vauquelin, and Thenard, by transmitting the vapour through a red-hot copper tube, or a porcelain one containing copper turnings. Both the first method, as employed by Berzelius, and the second, concur in showing the carburet to consist of

1 prime of carbon,	0·75	15·79
2 primes of sulphur,	4·00	84·21
	4·75	100·00

Vauquelin's experimental numbers are, from 15 to 16 carbon, and from 86 to 85 sulphur; and those of Berzelius and Marcet are 15·17 carbon, and 84·83 sulphur, in 100 parts.

Of the cold produced by the evaporation of the carburet of sulphur, the following account is given by Dr. Thomson in the third volume of his Annals, being the extract of a letter which he received from Mr. J. Murray, philosophical lecturer:—"A glass of water has remained on the table since the preceding evening, and though it might be some degrees below 32° Fahr. it indicated no disposition for congelation. A few drops of sulphuret of carbon were applied to the surface; instantly the globules became cased with a shell of icy spiculæ of retiform texture. Where they were in contact with the water, plumose branches darted from the sulphuret as from a centre to the bottom of the vessel, and the whole became solidified. The sulphuret of carbon in the interim volatilized; and during this period the spicules exhibited the colours of the solar spectrum in beautiful array."

CARBURETTED HYDROGEN GAS. Of this compound gas, formerly called *heavy inflammable air*, we have two species, differing in the proportions of the constituents. The first, consisting of 1 prime equivalent of each, is carburetted hydrogen; the second, of 1 prime of carbon, and 2 of hydrogen, is subcarburetted hydrogen. 1. Carburetted hydrogen, the percarburetted hydrogen of the French chemists, is, according to Mr. Brande, the only definite compound of these two elements. To prepare it, we mix, in a glass retort, 1 part of alcohol and 4 of sulphuric acid, and expose the retort to a moderate heat. The gas is usually received over water; though De Saussure states that this liquid absorbs more than 1-7th of its volume of the gas. It is destructive of animal life. Its specific gravity is 0·978, according to Saussure. 100 cubic inches weigh 28·80 gr. It possesses all the mechanical properties of air. It is invisible and void of taste and smell, when it has been washed from a little ethereous vapour. The effect of heat on this gas is curious. When passed through a porcelain tube, heated to a cherry-red, it lets fall a portion of charcoal, and nearly doubles its volume. At a higher temperature it deposits more charcoal, and augments in bulk; till finally, at the greatest heat to which we can expose it, it lets fall almost the whole of its carbon, and assumes a volume 3½ times greater than it had at first. These remarkable results, observed with great care, have induced the illustrious Berthollet to conclude, with much plausibility, that hydrogen and carbon combine in many successive proportions. The transmission of a series of electric sparks through this gas produces a similar effect with that of simple heat.

Carburetted hydrogen burns with a splendid white flame. When mixed with three times its bulk of oxygen, and kindled by a taper or the electric spark, it explodes with great violence, and the four volumes are converted into two volumes of carbonic acid. But two volumes of carbonic acid contain two volumes of oxygen. The remaining volume of oxygen therefore has been expended in forming water with two volumes of hydrogen. Hence the original volume of carburetted hydrogen was made up of these two volumes of hydrogen = 0·1388 (0·0694 × 2) + 2 volumes of gaseous carbon = 0·8333, constituting 1 condensed volume = 0·9722. By gaseous carbon is meant the vapour of this solid, as it exists in carbonic acid; the density of which vapour is found by subtracting the specific gravity of oxygen from that of carbonic acid. Hence 1·5277 — 1·1111 = 0·4166, represents the density of gaseous carbon. M. Thenard says, that if we mix the percarburetted hydrogen at once with three times its volume of oxygen, the eudiometer would be broken; so sudden and powerful is the expansion. The eudiometer referred to is that of Volta, which costs three guineas in Paris. My eudiometer, which does not cost three shillings, bears the explosive violence of the above mixture, without any danger. (See EUDIOMETER). When it is detonated with only an equal volume of oxygen, it expands greatly, and the two volumes become more than three and a half. In this case only 1-8th or 1-10th of a volume of carbonic acid is formed, but more than a volume and a half of carbonic oxide: a little hydrogen is consumed, but the greatest part remains untouched and mixed with the carbonic oxide. It may be separated by combustion with chlorine.

If we refer the weights above found, from the combining volumes, to the equivalent oxygen scale, we shall have the gas consisting of 1 prime of each constituent.

For 0·1388 : 0·125 : : 8333 : 0·752; now 0·125 and 0·750 represent the prime equivalents of hydrogen and carbon.

When this gas is mixed with its own bulk of chlorine, the gaseous mixture is condensed over water into a peculiar oily-looking compound. Hence this carburetted hydrogen was called by its discoverers, the associated Dutch chemists, *olefiant gas*. MM. Robiquet and Colin formed this liquid in considerable quantities, by making two currents of its constituent gases meet in a glass globe. The olefiant gas should be in rather larger quantity than the chlorine, otherwise the liquid becomes of a green colour, and acquires acid properties. When it is washed with water, and distilled off dry muriate of lime, it may be regarded as pure. It is then a limpid colourless essence of a pleasant flavour, and a sharp, sweet, and not disagreeable taste. At 45° its specific gravity is 2·2201. Its boiling point is 152°. At 49° its vapour is said to be capable of sustaining a column of 24⅜ inches of mercury. The specific gravity of the vapour is 3.4434, compared to atmospheric air. But that quantity is the sum of the densities of chlorine and olefiant gas. It will consist therefore by weight of

Olefiant gas,	0·9722	(2 × 0·875)	1·75
Chlorine,	2·500		4·50
	3·4722		6·25

or two primes of the first, and one of the second. Its ultimate constituents are therefore 1 chlorine, 2 carbon, and 2 hydrogen. This essence burns with a green flame, from which charcoal is deposited, and muriatic acid gas flies off. Decomposition, with similar results, is effected by passing the liquid through a red-hot porcelain tube. Its constitution probably resembles that of muriatic ether.

Olefiant gas is elegantly analyzed by heating sulphur in it over mercury. One cubic inch of it, with 2 grains of sulphur, yields 2 cubic inches of sulphuretted hydrogen, and charcoal is deposited. Now we know that the latter gas contains just its own volume of hydrogen.

2. Subcarburetted hydrogen. This gas is supposed to be procured in a state of definite composition, from the mud of stagnant pools or ditches. We have only to fill a wide-mouthed goblet with water, and inverting it in the ditch-water, stir the bottom with a stick. Gas rises into the goblet.

The fire-damp of mines is a similar gas to that of ditches. There is in both cases an admixture of carbonic acid, which lime or potash water will remove. A proportion of air is also present, the quantity of which can be ascertained by analysis. By igniting acetate of potash in a gun-barrel, an analogous species of gas is obtained. According to M. Berthollet, the sp. gr. of the carburetted hydrogen from ditch mud, exclusive of the azote, is 0·5382.

Subcarburetted hydrogen is destitute of colour, taste, and smell. It burns with a yellow flame, like that of a candle. When mixed with twice its volume of oxygen and exploded, we obtain exactly its own bulk of carbonic acid, while water is precipitated. We can hence infer the composition of subcarburetted hydrogen. For of the two volumes of oxygen, one remains gaseous in the carbonic acid, and another is condensed with two volumes of hydrogen into water. 1 volume of vapour of carbon + 2 volumes of hydrogen, condensed into 1 volume, compose subcarburetted hydrogen gas. Thus in numbers,

1 volume of gaseous carbon	=0.4166		0.75	= 1 prime
2 do. hydrogen	=0.1388	(0.125 × 2) =	0.25	= 2 primes
	0.5554		1.00	

Here we see the specific gravity 0·5554 is very near the determination of Berthollet. We also perceive the compound prime to be 1·000, the same as oxygen. Berthollet says that the carburetted hydrogen obtained by exposing olefiant gas to an intense heat contains 2 of hydrogen to 1 of carbon by weight. This proportion corresponds to

12 primes of hydrogen = 1·5
And 1 do. of carbon = 0·75

As the gas of ditches and the choke-damp of mines is evidently derived from the action of water on decaying vegetable or carbonaceous matter, we can understand that a similar product will be obtained by passing water over ignited charcoal, or by heating moistened charcoal or vegetable matter in retorts. The gases are here, however, a somewhat complex mixture, as well as what we obtain by igniting pit-coal and wood in iron retorts. (See Coal Gas). The combustion of subcarburetted hydrogen with common air takes place only when they are mixed in certain proportions. If from 6 to 12 parts of air be mixed with one of carburetted hydrogen, we have explosive mixtures. Proportions beyond these limits will not explode. In like manner, from 1 to 2½ of oxygen must be mixed with one of the combustible gas, otherwise we have no explosion. Sir H. Davy says that this gas has a disagreeable empyreumatic smell, and that water absorbs 1-30th of its volume of it. See Oil Gas.

CARICA PAPAYA. Papaw tree. Every part of the papaw tree, except the ripe fruit, affords a milky juice, which is used in the Isle of France as an effectual remedy for the tape-worm. In Europe, however, whither it has been sent in the concrete state, it has not answered.

The most remarkable circumstance regarding the papaw tree, is the extraction from its juice of a matter exactly resembling the flesh or fibre of animals, and hence called vegetable *fibria*; which see.

CARINTHINE. A sub-species of the mineral Augite. Colour black. Occurs massive and disseminated. Internally splendent. Resino-vitreous. Distinct cleavage of 124° 34′. Fracture conchoidal. Greenish-black variety; translucent on the edges, velvet-black, opaque. Occurs in the Saualpe in Carinthia, in a bed in primitive rock, associated with quartz, kyanite, garnet, and zoizite.—*Jameson.*

CARMINE. A red pigment prepared from cochineal. See Lake.

CARNELIAN is a sub-species of calcedony. Its colours are white, yellow, brown, and red. It has a conchoidal fracture, and a specific gravity of 2.6. It is semitransparent, and has a glistening lustre. It consists of 94 silica, 3.5 alumina, and 0.75 oxide of iron. The finest specimens come from Cambay and Surat in India. It is found in the channels of torrents in Hindostan, in nodules of a blackish-olive, passing into grey. After exposure for some weeks to the sun, these are subjected to heat in earthen pots, whence proceed the lively colours for which they are valued in jewellery. It is softer than common calcedony.

CAROMEL. The smell exhaled by sugar, at a calcining heat.

CARPHOLITE. This mineral is yellow, but sometimes colourless. It occurs in minute crystals, generally in a radiating form; also amorphous. In this state it is white. Sp. grav. 2.935. It consists of, silica 37.53; alumina 26.47; oxide of manganese 18.33; protoxide of iron 6.27; water 11.36. It fuses at the blowpipe with intumescence, whitens, and then becomes a brown opaque glass. It is found at Schlackenwalde in Bohemia. *Phillips's Mineralogy.*

CARTHAMUS, SAFFLOWER, or BASTARD SAFFRON. In some of the deep reddish, yellow, or orange-coloured flowers, the yellow matter seems to be of the same kind with that of the pure yellow flowers; but the red to be of a different kind from the pure red ones. Watery menstrua take up only the yellow, and leave the red, which may afterward be extracted by alcohol, or by a weak solution of alkali. Such particularly are the saffron-coloured flowers of carthamus. These, after the yellow matter has been extracted by water, are said to give a tincture to ley; from which, on standing at rest for some time, a deep red fecula subsides, called safflower, and from the countries whence it is commonly brought to us, Spanish red and China lake. This pigment impregnates alcohol with a beautiful red tincture; but communicates no colour to water.

Rouge is prepared from carthamus. For this purpose the red colour is extracted by a solution of the subcarbonate of soda, and precipitated by lemon juice previously depurated by standing. This precipitate is dried on earthen plates, mixed with talc, or French chalk, reduced to a powder by means of the leaves of shave-grass, triturated with it till they are both very fine, and then sifted. The fineness of the powder and proportion of the precipitate constitute the difference between the finer and cheaper rouge. It is likewise spread very thin on saucers, and sold in this state for dyeing.

Carthamus is used for dyeing silk of a poppy, cherry, rose, or bright orange-red. After the yellow matter is extracted as above, and the cakes opened, it is put into a deal trough, and sprinkled at different times with pearl ashes, or rather soda, well powdered and sifted, in the proportion of six pounds to a hundred, mixing the alkali well as it is put in. The alkali should be saturated with carbonic acid. The carthamus is then put on a cloth in a trough with a grated bottom, placed on a larger trough, and cold water poured on, till the larger trough is filled. And this is repeated, with the addition of a little more alkali toward the end, till the carthamus is exhausted and become yellow. Lemon juice is then poured into the bath, till it is turned of a fine cherry colour, and after it is well stirred, the silk is immersed in it. The silk is wrung, drained, and passed through fresh baths, washing and drying after every operation, till it is of a proper colour; when it is brightened in hot water and lemon juice. For a poppy or fire colour a slight annotto ground is first given; but the silk should not be alumed. For a pale carnation a little soap should be put into the bath. All these baths must be used as soon as they are made, and cold, because heat destroys the colour of the red feculæ.

CARTILAGE. An elastic, semitransparent, animal solid, which remains of the shape, and one-third the weight of the bones, when the calcareous salts are removed by digestion in dilute muriatic acid. It resembles coagulated albumen. Nitric acid converts it into gelatin. With alkalis it forms an animal soap. Cartilage is the primitive paste, into which the calcareous salts are deposited in the young animal. In the disease rickets, the earthy matter is withdrawn by morbid absorption, and the bones return into the state nearly of flexible cartilage. Hence arise the distortions characteristic of this disease.

CASE-HARDENING. Steel when hardened is brittle, and iron alone is not capable of receiving the hardness steel may be brought to possess. There is nevertheless a variety of articles in which it is desirable to possess all the hardness of steel, together with the toughness of iron. These requisites are united in the art of case-hardening, which does not differ from the making of steel, except in the shorter duration of the process. Tools, utensils, or ornaments intended to be polished, are first manufactured in iron and nearly finished, after which they are put into an iron box, together with vegetable or animal coals in powder, and cemented for a certain time. This treatment converts the external part into a coating of steel, which is usually very thin, because the time allowed for the cementation is much shorter than when the whole is intended to be made into steel. Immersion of the heated pieces into water hardens the surface, which is afterward polished by the usual methods. Moxon's Mechanic Exercises, p. 56. gives the following receipt:—Cow's horn or hoof is to be baked or thoroughly dried, and pulverized. To this add an equal quantity of bay salt: mix them with stale chamberley, or white wine vinegar: cover the iron with this mixture, and bed it in the same in loam, or enclose it in an iron box: lay it then on the hearth of the forge to dry and harden: then put it into the fire, and blow till the lump have a blood-red heat, and no higher, lest the mixture be burned too much. Take the iron out, and immerse it in water to harden.

CASEIC ACID. The name which Proust gave to a substance of an acid nature, which he extracted from cheese; and to which he ascribes many of the properties of this species of food.

CASSAVA. An American plant, the *jatropha manihot*, contains the nutritive starch cassava, curiously associated with a deadly poisonous juice. The roots of *jatropha* are squeezed in a bag. The cassava remains in it; and the juice, which is used by the Indians to poison their arrows, gradually lets fall some starch of an innocent and very nutritious quality. The whole solid matter is dried in smoke, ground, and made into bread.

CASSIUS'S Purple Precipitate. See Gold.

CASTOR. A soft greyish-yellow or light-brown substance, found in four bags in the inguinal region of the beaver. In a warm air it grows by degrees hard and brittle, and of a darker colour, especially when dried in chimneys, as is usually done. According to Bouillon La Grange, it consists of a mucilage, a bitter extract, a resin, an essential oil, in which its peculiar smell appears to reside, and a flaky crystalline matter, much resembling the adipocere of biliary calculi.

Castor is regarded as a powerful antispasmodic.

CASTORINA. A light powder precipitated from alcohol which had been boiled for some time on one sixth its weight of castor. On redissolution in hot alcohol, prismatic acicular crystals were obtained; diaphanous and white. These dissolve readily in ether. When heated they fuse and appear to boil, emitting vapours which burn brilliantly in the air. They do not give ammonia in destructive distillation. *Bizio* in the *Gior. de Fisica*, vii. 174.

CATECHU. A brown astringent substance, formerly known by the name of *Japan earth*. It is a dry extract, prepared from the wood of a species of sensitive plant, the *mimosa catechu*. It is imported into this country from Bombay and Bengal. According to Sir H. Davy, who analyzed it, that from Bombay is of uniform texture, red-brown colour, and specific gravity 1.39: that from Bengal is more friable and less consistent, of a chocolate colour externally, but internally chocolate streaked with red-brown, and specific gravity 1.28. The catechu from either place differs little in its properties. Its taste is astringent, leaving behind a sensation of sweetness. It is almost wholly soluble in water.

Two hundred grains of picked catechu from Bombay afforded 109 grains of tannin, 68 extractive matter, 13 mucilage, 10 residuum, chiefly sand and calcareous earth. The same quantity from Bengal: tannin 97 grains, extractive matter 73, mucilage 16, residual matter, being sand, with a small quantity of calcareous and aluminous earths, 14. Of the latter, the darkest parts appeared to afford most tannin, the lightest most extractive matter. The Hindoos prefer the lightest coloured, which has probably most sweetness, to chew with the betel-nut.

Of all the astringent substances we know, catechu appears to contain the largest proportion of tannin; and Mr. Purkis found, that one pound was equivalent to seven or eight of oak bark for the purpose of tanning leather.

As a medicine it has been recommended as a powerful astringent, and a tincture of it is used for this purpose; but its aqueous solution is less irritating. Made into troches with gum arabic and sugar, it is an elegant preparation, and in this way is said much to assist the clearness of the voice, and to be remarkably serviceable in disorders of the throat.

CAT'S EYE. A mineral of a beautiful appearance, brought from Ceylon.

Its colours are grey, green, brown, red, of various shades. Its internal lustre is shining, its fracture imperfectly conchoidal, and it is translucent. From a peculiar play of light, arising from white fibres interspersed, it has derived its name. The French call the appearance *chatoyant*. It scratches quartz, is easily broken, and resists the blowpipe. Its sp. gr. is 2.64. Its constituents are, according to Klaproth, 95 silica, 1.75 alumina, 1.5 lime, and 0.25 oxide of iron. It is valued for setting as a precious stone.

CAUSTIC (LUNAR). Fused nitrate of silver. See SILVER.

CAUSTICITY. All substances which have so strong a tendency to combine with the principles of organized substances as to destroy their texture, are said to be caustic. The chief of these are the concentrated acids, pure alkalis, and the metallic salts.

CAUTERY (POTENTIAL). See CAUSTIC.

CAWK. A term by which the miners distinguish the opaque specimens of sulphate of barytes.

CELESTINE. Native sulphate of strontites. This mineral is so named from its occasional delicate blue colour; though it is frequently found of other shades, as white, greyish, and yellowish white and red. It occurs both massive and crystallized. Sometimes also in fibrous and stellated forms. According to Haüy, the primitive form is a right rhomboidal prism, of 104° 48′ and 75° 12′. The reflecting goniometer makes these angles 104° and 76°. The varieties of its crystals may be referred to four or six-sided prisms, terminated by two, four, or eight-sided summits. It has a shining lustre, and is either transparent, translucent, or opaque. It scratches calcareous spar, but is scratched by fluor. It is very brittle. Its sp. gr. is 3.6. Before the blowpipe it fuses into a white, opaque, and friable enamel.

The three sub-species are, 1st, The compact found in Montmartre near Paris, of a yellowish-grey colour, in rounded pieces, of a dull lustre, opaque, and consisting, by Vauquelin's analysis, of 91.42 sulphate of strontites, 8.33 carbonate of lime, and 0.25 oxide of iron. 2d, The fibrous, whose colours are indigo-blue and bluish-grey; sometimes white. It occurs both massive and crystallized. Shining and somewhat pearly lustre. It is translucent. Sp. grav. 3.83. 3d, The foliated, of a milk-white colour, falling into blue. Massive and in grouped crystals, of a shining lustre and straight foliated texture. Translucent. Celestine occurs most abundantly near Bristol in the red marle formation; and crystallized in red sandstone, at Inverness in Scotland.

Mr. Gruner Ober Berg of Hanover has lately favoured the world with an analysis of [illegible] crystallized celestine, found in the neighbo[illegible]hood of that city, of rather peculiar composition. Its sp. gr. is only 3.59, and yet it contains a large proportion of sulphate of barytes:

Sulphate of strontites,	73.000
Sulphate of barytes,	26.166
Ferruginous clay,	0.213
Loss,	0.621
	100.000

Had the result been 75 of sulphate of strontites + 25 sulphate of barytes, we should have considered the mineral as a compound of 4 primes of the first salt + 1 of the second. Now the analysis, in my opinion, cannot be confided in within these limits; for the mingled muriates of the earths were separated by digestion in 16 times their weight of boiling alcohol, of a strength not named. Besides, the previous perfect conversion of the sulphates into carbonates, by merely fusing the mineral with thrice its weight of carbonate of potash, is, to say the least, problematical. Dr. Thomson adapts M. Ober Berg's analysis to 7 atoms of sulphate of strontian, and 2 atoms of sulphate of barytes.

CEMENT. Whatever is employed to unite or cement together things of the same or different kinds, may be called a *cement*. In this sense it includes LUTES, GLUES, and SOLDERS of every kind, which see; but it is more commonly employed to signify those of which the basis is an earth or earthy salt. See LIME. We shall here enumerate, chiefly from the Philosophical Magazine, some cements that are used for particular purposes.

Seven or eight parts of resin, and one of wax, melted together, and mixed with a small quantity of plaster of Paris, is a very good cement to unite pieces of Derbyshire spar, or other stone. The stone should be made hot enough to melt the cement, and the pieces should be pressed together as closely as possible, so as to leave as little as may be of the cement between them. This is a general rule in cementing, as the thinner the stratum of cement interposed, the firmer it will hold.

Melted brimstone used in the same way will answer sufficiently well, if the joining be not required to be very strong.

It sometimes happens, that jewellers, in setting precious stones, break off pieces by accident; in this case they join them so that it cannot easily be seen, with gum mastic, the stone being previously made hot enough to melt it. By the same medium cameos of white enamel, or coloured glass, are often joined to a real stone as a ground, to produce the appearance of an onyx. Mastic is likewise used to cement false backs or doublets to stones, to alter their hue.

The jewellers in Turkey, who are generally Armenians, ornament watch-cases and other trinkets with gems, by glueing them on. The stone is set in silver or gold, and the back of the setting made flat to correspond with the part to which it is to be applied. It is then fixed on with the following cement: Isinglass, soaked in water till it swells up and becomes soft, is dissolved in French brandy, or in rum, so as to form a strong glue. Two small bits of gum galbanum, or gum ammoniacum, are dissolved in two ounces of this by trituration; and five or six bits of mastic, as big as pease, being dissolved in as much alcohol as will render them fluid, are to be mixed with this by means of a gentle heat. This cement is to be kept in a phial closely stopped; and when used, it is to be liquefied by immersing the phial in hot water. This cement resists moisture.

A solution of shell lac in alcohol, added to a solution of isinglass in proof spirit, makes another cement that will resist moisture.

So does common glue melted without water, with half its weight of resin, with the addition of a little red ochre to give it a body. This is particularly useful for cementing hones to their frames.

If clay and oxide of iron be mixed with oil, according to Mr. Gad of Stockholm, they will form a cement that will harden under water.

A strong cement, insoluble in water, may be made from cheese. The cheese should be that of skimmed milk, cut into slices, throwing away the rind, and boiled till it becomes a strong glue, which, however, does not dissolve in the water. This water being poured off, it is to be washed in cold water, and then kneaded in warm water. This process is to be repeated several times. The glue is then to be put warm on a levigating stone, and kneaded with quicklime. This cement may be used cold, but it is better to warm it; and it will join marble, stone, or earthen-ware, so that the joining is scarcely to be discovered.

Boiled linseed oil, litharge, red lead, and white lead, mixed together to a proper consistence, and applied on each side of a piece of flannel, or even linen or paper, and put between two pieces of metal before they are brought home, or close together, will make a close and durable joint, that will resist boiling water, or even a considerable pressure of steam. The proportions of the ingredients are not material; but the more the red lead predominates, the sooner the cement will dry, and the more the white lead, the contrary. This cement answers well for joining stones of any dimensions.

The following is an excellent cement for iron, as in time it unites with it into one mass. Take two ounces of muriate of ammonia, one of flowers of sulphur, and 16 of cast-iron filings or borings. Mix them well in a mortar, and keep the powder dry. When the cement is wanted for use, take one part of this mixture, twenty parts of clear iron borings or *filings*, grind them together in a mortar, mix them with water to a proper consistence, and apply them between the joints.

Powdered quicklime mixed with bullock's blood is often used by coppersmiths, to lay over the rivets and edges of the sheets of copper in large boilers, as a security to the junctures, and also to prevent cocks from leaking.

Six parts of clay, one of iron filings, and linseed oil sufficient to form a thick paste, make a good cement for stopping cracks in iron boilers.

Temporary cements are wanted in cutting, grinding, or polishing optical glasses, stones, and various small articles of jewellery, which it is necessary to fix on blocks, or handles, for the purpose. Four ounces of resin, a quarter of an ounce of wax, and four ounces of whiting made previously red hot, form a good cement of this kind; as any of the above articles may be fastened to it by heating them, and removed at pleasure in the same manner, though they adhere very firmly to it when cold. Pitch, resin, and a small quantity of tallow, thickened with brick-dust, is much used at Birmingham for these purposes. Four parts of resin, one of bees' wax and one of brick-dust, likewise make a good cement. This answers extremely well for fixing knives and forks in their hafts; but the manufacturers of cheap articles of this kind too commonly use resin and brick-dust alone. On some occasions, in which a very tough cement is requisite, that will not crack though exposed to repeated blows, as in fastening to a block metallic articles that are to be cut with a hammer and punch, workmen usually mix some tow with the cement, the fibres of which hold its parts together.

Mr. Singer recommends the following composition as a good cement for electrical apparatus: Five pounds of resin, one of bees' wax, one of red ochre, and two table spoonfuls of plaster of Paris, all melted together. A cheaper one for cementing voltaic plates into wooden troughs is made with six pounds of resin, one pound of red ochre, half a pound of plaster of Paris, and a quarter of a pint of linseed oil. The ochre and plaster of Paris should be well dried, and added to the other ingredients, in a melted state.

Analysis of water cements by Sir Humphrey Davy.

Mr. Parker's patent cement.

	50 grains contain	100 gr.
Silex, - -	11	22
Alumina, - -	4.5	9
Oxide of Iron, And manganese,	6.5	13
Carbonate of lime,	27.5	55
		99
50 grains lost by heating,	1⅝	3.25
		102.25

Loftus.

	50 grains contain	100 gr.
Silex, - -	12.75	25.5
Alumina, - -	2.5	5.
Oxide of iron, And manganese,	5.25	10.5
Carbonate of lime,	27.75	55.5
		96.5
Loss by heat, -	1.25	2.5
		99

Mulgrave.

	50 grains contain	100 gr.
Silex, - -	10.5	21
Alumina, - -	3.75	7.5
Oxide of iron, And manganese,	6.75	13.5
Carbonate of lime, -	27.5	55
		97
Loss, - -	1.62	3.32
		100.32.

M. Bruyere finds that an excellent artificial water cement may be obtained by heating a mixture of three parts clay, and one part slaked lime by measure, for some hours to redness. *Ann. de Mines*, ix. 550.

CEMENT, for buildings. See LIME.

CEMENTATION. A chemical process, which consists in surrounding a body in the solid state with the powder of some other bodies, and exposing the whole for a time in a closed vessel, to a degree of heat not sufficient to fuse the contents. Thus iron is converted into steel by cementation with charcoal; green bottle glass is converted into porcelain by cementation with sand, &c. See IRON and PORCELAIN.

CERASIN. The name given by Dr. John of Berlin to those gummy substances which swell in cold water, but do not readily dissolve in it. Cerasin is soluble in boiling water, but separates in a jelly when the water cools. Water acidulated with sulphuric, nitric, or muriatic acid, by the aid of a gentle heat, forms a permanent solution of cerasin. Gum tragacanth is the best example of this species of vegetable product.

CERATE. The compound of oil or lard with bees' wax, used by surgeons to screen ulcerated surfaces from the air.

CERIN. A peculiar substance which precipitates, on evaporation, from alcohol, which has been digested on grated cork. Subercerin would have been a fitter name. Chevreul, the discoverer, describes this substance as consisting of small white needles, which sink and merely soften in boiling water. 1000 parts of boiling alcohol dissolve 2.42 of cerin, and only 2 of wax. Nitric acid converts it into oxalic acid. It is insoluble in an alcoholic solution of potash.

CERIN. The name given by Dr. John to the part of common wax which dissolves in alcohol.

CERIN. A variety of the mineral *allanite*, lately examined by Berzelius. It consists of oxide of cerium 28.19, oxide of iron 20.72, oxide of copper 0.87, silica 30.17, alumina 11.31, lime 9.12, volatile matter 0.40.

CERITE. The siliciferous oxide of cerium. This rare mineral is of a rose-red or flesh-red colour, occasionally tinged with clove-brown. Its powder is reddish-grey. It is found massive and disseminated. Internal lustre resinous, but scarcely glimmering. Its fracture is fine splintery, with indeterminate fragments. It is opaque, scratches glass, gives sparks with steel, is difficult to break, scarcely yields to the knife, and gives a greyish-white streak. It is infusible before the blowpipe; but heat changes the grey colour of the powder to yellow. It consists, by Hisinger's analysis, of 18 silica, 68.59 oxide of cerium, 2 oxide of iron, 1.25 lime, 9.6 water and carbonic acid, and 0.56 loss, in 100 parts. Klaproth found 54.5 oxide of cerium, and 34.5 silica, in the hundred parts. It is found only in the copper mine of Bastnaes near Riddarhytta in Sweden, accompanied by the ores of copper, molybdena, and bismuth. Its sp. gr. is from 4.6 to 4.9.

CERIUM. The metal whose oxide exists in the preceding mineral.

To obtain the oxide of the new metal, the cerite is calcined, pulverized, and dissolved in nitromuriatic acid. The filtered solution being neutralized with pure potash, is to be precipitated by tartrate of potash; and the precipitate, well washed, and afterward calcined, is oxide of cerium.

The attempts to obtain the pure metal, by igniting the oxide, purified from iron by oxalic acid, in contact with tartaric acid, oil, and lamp-black, have in a great measure failed; only white brittle carburet was obtained.

Cerium is susceptible of two stages of oxidation; in the first it is white, and this by calcination becomes of a fallow-red.

The white oxide exposed to the blowpipe soon becomes red, but does not melt, or even agglutinate. With a large proportion of borax it fuses into a transparent globule.

The white oxide becomes yellowish in the open air, but never so red as by calcination, because it absorbs carbonic acid, which prevents its saturating itself with oxygen, and retains a portion of water, which diminishes [illegible] colour.

Alkalis do not act on it; but caustic potash in the dry way takes part of the oxygen from the red oxide, so as to convert it into the white without altering its nature.

The protoxide of cerium is composed by Hisinger of 85.17 metal + 14.83 oxygen, and the peroxide of 79.3 metal + 20.7. The protoxide has been supposed a binary compound of cerium 5.75 + oxygen 1, and the peroxide a compound of 5.75 × 2 of cerium + 3 oxygen. An alloy of this metal with iron was obtained by Vauquelin.

The salts of cerium are white or yellow-coloured, have a sweet taste, yield a white precipitate with hydrosulphuret of potash, but none with sulphuretted hydrogen; a milk-white precipitate, soluble in nitric and muriatic acids, with ferroprussiate of potash and oxalate of ammonia, none with infusion of galls, and a white one with arseniate of potash.

Equal parts of sulphuric acid and red oxide, with four parts of water, unite by the assistance of heat into a crystalline mass; which may be completely dissolved by adding more acid, and heating them together a long time. This solution yields, by gentle evaporation, small crystals, some of an orange, others of a lemon colour. The sulphate of cerium is soluble in water only with an excess of acid. Its taste is acid and saccharine. The sulphuric acid combines readily with the white oxide, particularly in the state of carbonate. The solution has a saccharine taste, and readily affords white crystals.

Nitric acid does not readily dissolve the red oxide without heat. With an excess of acid, white deliquescent crystals are formed, which are decomposable by heat. Their taste is at first pungent, afterward very sugary. The white oxide unites more readily with the acid.

Muriatic acid dissolves the red oxide with effervescence. The solution crystallizes confusedly. The salt is deliquescent, soluble in an equal weight of cold water, and in three or four times its weight of alcohol. The flame of this solution, if concentrated, is yellow and sparkling; if not, colourless; but on agitation it emits white, red, and purple sparks.

Carbonic acid readily unites with the oxide. This is best done by adding carbonate of potash to the nitric and muriatic solution of the white oxide, when a light precipitate will be thrown down, which on drying assumes a shining silvery appearance, and consists of 23 acid + 65 oxide + 12 water.

The white oxide unites directly with tartaric acid, but requires an excess to render it soluble. See SALT.

CERUMEN of the ear. It is a yellow-coloured secretion, which lines the external auditory canal, rendered viscid and concrete by exposure to air. It has a bitter taste, melts at a low heat, and evolves a slightly aromatic odour. On ignited coals, it gives out a white smoke, similar to that of burning fat, swells, emits a fetid ammoniacal odour, and is converted into a light coal. Alcohol dissolves ⅝ of it, and on evaporation leaves a substance resembling the resin of bile. The ⅜ which remain are albumen mixed with oil, which by incineration leave soda and phosphate of lime. Hence, the whole constituents are five; albumen, an inspissated oil, a colouring matter, soda, and calcareous phosphate.

CERUSE, or WHITE LEAD. See LEAD.

CETINE. The name given by Chevreul to spermaceti. According to Berard, who analyzed it on M. Gay Lussac's plan, by passing its vapour through ignited peroxide of copper, *cetine* consists of 81 carbon, 6 oxygen, and 13 hydrogen, in 100 parts.

CEYLANITE. This mineral, the pleonaste of Haüy, comes from Ceylon, commonly in rounded pieces, but occasionally in crystals. The primitive form of its crystals is a regular octohedron, in which form, or with the edges truncated, it frequently occurs. Its colour is indigo-blue, passing into black, which on minute inspection appears greenish. It has a rough surface, with little external lustre, but splendent internally. The fracture is perfect flat conchoidal, with very sharp-edged fragments. It scarcely scratches quartz, and is softer than spinell. It is easily broken, has a sp. gr. of 3.77, and is infusible by the blowpipe.

CHABASITE. This mineral occurs in crystals, whose primitive form is nearly a cube, since the angle at the summit is only 93⅓°. It is found in that form, and also with 6 of its edges truncated, and the truncatures united 3 and 3 at the two opposite angles, while the other six angles are truncated. It occurs also in double six-sided pyramids, applied base to base, having the six angles at the base, and the three acute edges of each pyramid truncated. It is white, or with a tinge of rose colour, and sometimes transparent. It scratches glass, fuses by the blowpipe into a white spongy mass, and has a sp. gr. of 2.72. Its constituents are 43.33 silica, 22.66 alumina, 3.34 lime, 9.34 soda and potash, water 21. It is found in scattered crystals in the fissures of some trap rocks, and in the hollows of certain *geodes*, disseminated in the same rocks.

It occurs in the quarry of Alteberg near Oberstein.

CHALK. A very common species of calcareous earth, of an opaque white colour, very soft, and without the least appearance of a polish in its fracture. Its specific gravity is from 2.4 to 2.6, according to Kirwan. It contains a little siliceous earth, and about two per cent. of clay. Some specimens, and perhaps most, contain a little iron, and Bergmann affirms that muriate of lime, or magnesia, is often found in it; for which reason he directs the powder of chalk to be several times boiled in distilled water, before it is dissolved for the purpose of obtaining pure calcareous earth.

CHALK (BLACK). Drawing slate. The colour of this mineral is greyish or bluish-black. Massive. The principal fracture is glimmering and slaty, the cross fracture dull, and fine earthy. It is in opaque, tabular fragments, stains paper black, streak glistening, and the same colour as the surface; easily cut and broken; sp. gr. 2.4; becomes red in the fire, and falls to pieces in water. It occurs in primitive mountains, often accompanied by alum slate. It is used in crayon drawing, whence its name.

CHALK STONES. Gouty concretions, whose true nature was first discovered by Dr. Wollaston, and described by him in his admirable dissertation on urinary calculi, published in the Phil. Trans. for 1797. See GOUTY CONCRETIONS.

CHALK (RED). This is a clay, coloured by the oxide of iron, of which it contains from 16 to 18 parts in the hundred, according to Rinman.

CHALK (SPANISH). The soap rock is frequently distinguished by this name.

CHALYBEATE. Said of a mineral water impregnated with iron.

CHAMELEON MINERAL. See CAMELEON.

CHARACTERS (CHEMICAL). The chemical characters were invented by the earlier chemists, probably with no other view than to save time in writing the names of substances that frequently occurred, in the same manner as we avoid repetitions by the use of pronouns. But the moderns seem to have considered them as relics of alchemistical obscurity, and have almost totally rejected their use. Very little of system appears in the ancient characters of chemists: the characters of Bergmann are chiefly grounded on the ancient characters, with additions and improvements. But the characters of Hassenfratz and Adet are systematical throughout. For myself, I regard them merely as the means of mystifying chemistry in the eyes of the uninitiated, and therefore unworthy of the liberal spirit of the age in which we live.

CHARCOAL. When vegetable substances are exposed to a strong heat in the apparatus for distillation, the fixed residue is called charcoal. For general purposes, wood is converted into charcoal by building it up in a pyramidal form, covering the pile with clay or earth, and leaving a few air-holes, which are closed as soon as the mass is well lighted; and by this means the combustion is carried on in an imperfect manner. In the forest of Benon, near Rochelle, great attention is paid to the manufacture, so that the charcoal made there fetches 25 or 30 per cent. more than any othe[illegible] The wood is that of the black oak. It is tak[illegible] from ten to fifteen years old, the trunk as well as the branches, cut into billets about four feet long, and not split. The largest pieces, however, seldom exceed six or seven inches in diameter. The end that rests on the ground is cut a little sloping, so as to touch it merely with an edge, and they are piled nearly upright, but never in more than one story. The wood is covered all over about four inches thick with dry grass or fern, before it is enclosed in the usual manner with clay; and when the wood is charred, half a barrel of water is thrown over the pile, and earth to the thickness of five or six inches is thrown on, after which it is left four-and-twenty hours to cool. The wood is always used in the year in which it is cut.

In charring wood it has been conjectured, that a portion of it is sometimes converted into a pyrophorus, and that the explosions that happen in powder-mills are sometimes owing to this.

Charcoal is made on the great scale, by igniting wood in iron cylinders, as I have described under ACID (ACETIC). When the resulting charcoal is to be used in the manufacture of gunpowder, it is essential that the last portion of vinegar and tar be suffered to escape, and that the reabsorption of the crude vapours be prevented, by cutting off the communication between the interior of the cylinders and the apparatus for condensing the pyroligneous acid, whenever the fire is withdrawn from the furnace. If this precaution be not observed, the gunpowder made with the charcoal would be of inferior quality.

In the third volume of Tilloch's Magazine, we have some valuable facts on charcoal by Mr. Mushet. He justly observes, that the produce of charcoal in the small way differs from that on the large scale, in which the quantity of char depends more upon the hardness and compactness of the texture of wood, and the skill of the workmen in managing the pyramid of faggots, than on the absolute quantity of carbon it contains. The following is his table of results, reduced to 100 parts, from experiments on one pound avoirdupois of wood.

Parts in 100.

	Volatile Matter.	Charcoal.	Ashes.	Charcoal by	
				Proust.	Rumford.
Oak,	76.895	22.682	0.423	20.	43.00
Ash,	81.260	17.972	0.768	17.	
Birch,	80.717	17.491	1.792		
Norway Pine,	80.441	19.204	0.355	20.	44.18
Mahogany,	73.528	25.492	0.980	Black Ash. 25.	
Sycamore,	79.20	19.734	1.066		
Holly,	78.92	19.918	1.162	Willow. 17.	
Scotch Pine,	83.095	16.456	0.449	Heart of Oak. 19.	
Beech,	79.104	19.941	0.955		
Elm,	79.655	19.574	0.761		43.27
Walnut,	78.521	20.663	0.816		
American Maple,	79.331	19.901	0.768		42.23
Do. Black Beech,	77.512	21.445	1.033	Guaiacum. 24.	
Laburnum,	74.234	24.586	1.180		
Lignum Vitæ,	72.643	26.857	0.500		Poplar. 43.57
Sallow,	80.371	18.497	1.132		
Chesnut,	76.304	23.280	0.416		Lime. 43.59

MM. Clement and Desormes say, that wood contains one-half its weight of charcoal. M. Proust says, that *good* pit-coals afford 70, 75, or 80 per cent. of charcoal or coke; from which only two or three parts in the hundred of ashes remain after combustion. *Tilloch's Mag.* vol. viii.

Charcoal is black, sonorous, and brittle, and in general retains the figure of the vegetable it was obtained from. If, however, the vegetable consist for the most part of water or other fluids, these in their extrication will destroy the connexion of the more fixed parts. In this case the quantity of charcoal is much less than in the former. The charcoal of oily or bituminous substances is of a light pulverulent form, and rises in soot. This charcoal of oils in called lamp-black. A very fine kind is obtained from burning alcohol.

Turf or peat has been charred lately in France, it is said by a peculiar process, and, according to the account given in Sonnini's Journal, is superior to wood for this purpose. Charcoal of turf kindles slower than that of wood, but emits more flame, and burns longer. In a goldsmith's furnace it fused eleven ounces of gold in eight minutes, while wood charcoal required sixteen. The malleability of the gold, too, was preserved in the former instance, but not in the latter. Iron heated red-hot by it in a forge, was rendered more malleable.

From the scarcity of wood in this country, pit-coal charred is much used instead of charcoal by the name of coke. See Carbon.

CHAY, or CHAYA-ROOT. This is the root of the *Oldenlandia umbellata*, which grows wild on the coast of Coromandel, and is likewise cultivated there for the use of the dyers and calico-printers. It is used for the same purposes as madder with us, to which it is said to be far superior, giving the beautiful red so much admired in the Madras cottons.

CHEESE. Milk consists of butter, cheese, a saccharine matter called sugar of milk, and a small quantity of common salt, together with much water.

If any vegetable or mineral acid be mixed with milk, the cheese separates, and, if assisted by heat, coagulates into a mass. The quantity of cheese is less when a mineral acid is used. Neutral salts, and likewise all earthy and metallic salts, separate the cheese from the whey. Sugar and gum-arabic produce the same effect. Caustic alkalis will dissolve the curd by the assistance of a boiling heat, and acids occasion a precipitation again. Vegetable acids have very little solvent power upon curd. This accounts for a greater quantity of curd being obtained when a vegetable acid is used. But what answers best is rennet, which is made by macerating in water a piece of the last stomach of a calf, salted and dried for this purpose.

Scheele observed, that cheese has a considerable analogy to albumen, which it resembles in being coagulable by fire and acids, soluble in ammonia, and affording the same products by distillation or treatment with nitric acid. There are, however, certain differences between them. Rouelle observed likewise a striking analogy between cheese and the gluten of wheat, and that found in the feculæ of green vegetables. By kneading the gluten of wheat with a little salt and a small portion of a solution of starch, he gave it the taste, smell, and unctuosity of cheese; so that after it had been kept a certain time, it was not to be distinguished from the celebrated Rochefort cheese, of which it had all the pungency. This caseous substance from gluten, as well as the cheese of milk, appears to contain acetate of ammonia, after it has been kept long enough to have undergone the requisite fermentation, as may be proved by examining it with sulphuric acid, and with potash. The pungency of strong cheese, too, is destroyed by alcohol.

In the 11th volume of Tilloch's Magazine there is an excellent account of the mode of making Cheshire cheese, taken from the Agricultural Report of the county. "If the milk," says the reporter, "be set together very warm, the curd, as before observed, will be firm; in this case, the usual mode is to take a common case-knife, and make incisions across it, to the full depth of the knife's blade, at the distance of about one inch; and again crossways in the same manner, the incisions intersecting each other at right angles. The whey rising through these incisions is of a fine pale green colour. The cheese-maker and two assistants then proceed to break the curd: this is performed by their repeatedly putting their hands down into the tub; the cheese-maker, with the skimming-dish in one hand, breaking every part of it as they catch it, raising the curd from the bottom, and still breaking it. This part of the business is continued till the whole is broken uniformly small; it generally takes up about 40 minutes, and the curd is then left covered over with a cloth for about half an hour to subside. If the milk has been set cool together, the curd, as before mentioned, will be much more tender, the whey will not be so green, but rather of a milky appearance."

CHEMISTRY may be defined the science which investigates the composition of material substances, and the permanent changes of constitution which their mutual actions produce.

CHENOPODIUM OLIDUM. A plant remarkable, according to MM. Chevalier and Lassaigne, for containing uncombined ammonia, which is probably the vehicle of the remarkably nauseous odour which it exhales, strongly resembling that of putrid fish. When the plant is bruised with water, and the liquor expressed and afterwards distilled, we procure a fluid which contains the subcarbonate of ammonia, and an oily matter, which gives the fluid a milky appearance. If the expressed juice of the chenopodium be evaporated to the consistence of an extract, it is found to be alkaline; there seems to be acetic acid in it. Its basis is said to be of an albuminous nature. It is stated also to contain a small quantity of the substance which the French call osmazome, a little of an aromatic resin, and a bitter matter, soluble both in alcohol and water, as well as several saline bodies. The following is stated as the result of their analysis, which, however, seems somewhat complex: 1. Subcarbonate of ammonia. 2. Albumen. 3. Osmazome. 4. An aromatic resin. 5. A bitter matter. 6. Nitrate of potash in large quantity. 7. Acetate and phosphate of potash. 8. Tartrate of potash. It is said that 100 parts of the dried plant produce 18 of ashes, of which 5½ are potash.

CHERT. See HORNSTONE.

CHIASTOLITE. A mineral crystallized in four-sided nearly rectangular prisms. On looking into the end of the prism, we perceive in the axis of it a blackish prism, surrounded by the other, which is of a greyish, yellowish, or reddish-white colour. From each angle of the interior prism, a blackish line extends to the corresponding angle of the exterior. In each of these outer angles there is usually a small rhomboidal space, filled with the same dark substance which composes the central prism. The black matter is the same clay-slate with the rock in which the chiastolite is embedded. Fracture, foliated with double cleavage. Translucent. Scratches glass. Rubbed on sealing-wax, it imparts negative electricity. Its sp. gr. is 2.94. Before the blowpipe it is convertible into a whitish enamel. The only mineral with which chiastolite or macle can be confounded, were it not crystallized, is steatite; but the latter communicates positive electricity to sealing-wax. It has been found in Britanny, in the Pyrenees, in the valley of Barege, and in Galicia in Spain, near St. James of Compostella. The interior of black crystal is properly an elongated four-sided pyramid.

CHILDRENITE. A mineral substance met with in Devonshire, supposed at first to be carbonate of iron; but shown by Dr. Wollaston to be a phosphate of alumina and iron. The crystals scratch glass; colour wine-yellow; occur in the surface of crystallized quartz, and might be mistaken for sulphate of barytes. *Mr. Brooke, in Annals of Phil.* vii. 316.

CHLORATES. Compounds of chloric acid with the salifiable bases. See ACID (CHLORIC.)

CHLORIC ACID. See ACID (CHLORIC.)

CHLORIDES. Compounds of chlorine with different bodies. See CHLORINE and the respective substances.

CHLORINE. The introduction of this term marks an era in chemical science. It originated from the masterly researches of Sir H. Davy on the oxymuriatic acid gas of the French school: a substance which, after resisting the most powerful means of decomposition which his sagacity could invent, or his ingenuity apply, he declared to be, according to the true logic of chemistry, an elementary body, and not a compound of muriatic acid and oxygen, as was previously imagined, and as its name seemed to denote. He accordingly assigned to it the term chlorine, descriptive of its colour; a name now generally used. The chloridic theory of combustion, though more limited in its applications to the chemical phenomena of nature, than the antiphlogistic of Lavoisier, may justly be regarded as of equal importance to the advancement of the science itself. When we now survey the Transactions of the Royal Society for 1808, 1809, 1810, and 1811, we feel overwhelmed with astonishment at the unparalleled skill, labour, and sagacity by which the great English chemist, [illegible] so short a space, prodigiously multiplied the objects and resources of the science, while he promulgated a new code of laws, flowing from views of elementary action, equally profound, original, and sublime. The importance of the revolution produced by his researches on chlorine will justify us in presenting a detailed account of the steps by which it has been effected. How entirely the glory of this great work belongs to Sir H. Davy, notwithstanding some invidious attempts in this country to tear the well-earned laurel from his brow, and transfer it to the French chemists, we may readily judge by the following decisive facts.

The second part of the Phil. Trans. for 1809 contains researches on oxymuriatic acid, its nature and combinations, by Sir H. Davy, from which I shall make a few interesting extracts.

"In the Bakerian lecture for 1808," says he, "I have given an account of the action of potassium upon muriatic acid gas, by which more than one-third of its volume of hydrogen is produced; and I have stated, that muriatic acid can in no instance be procured from oxymuriatic acid, or from dry muriates, unless water or its elements be present.

"In the second volume of the *Mémoires* D'Arcueil, MM. Gay Lussac and Thenard have detailed an extensive series of facts, upon muriatic acid, and oxymuriatic acid. Some of their experiments are similar to those I have detailed in the paper just referred to; others are peculiarly their own, and of a very curious kind: their general conclusion is, that muriatic acid gas contains about one quarter of its weight of water; and that oxymuriatic acid is not decomposable by any substances but hydrogen, or such as can form triple combinations with it.

"One of the most singular facts that I have observed on this subject, and which I have before referred to, is that charcoal, even when ignited to whiteness in oxymuriatic or muriatic acid gases, by the voltaic battery, effects no change in them, if it has been previously freed from hydrogen and moisture by intense ignition *in vacuo*.

"This experiment, which I have several times repeated, led me to doubt of the existence of oxygen in that substance, which has been supposed to contain it, above all others, in a loose and active state; and to make a more rigorous investigation, than had hitherto been attempted for its detection."

He then proceeds by experiment and reasoning to prove the true constitution of this muriatic essence. The above paper, and his Bakerian lecture, read before the Royal Society in Nov. and Dec. 1810, and published in the first part of their Transactions for 1811, present the whole body of evidence for the undecompounded nature of oxymuriatic acid gas, thenceforward styled chlorine; and they will be studied in every enlightened age and country, as a just and splendid pattern of inductive Baconian logic. These views were slowly and reluctantly admitted by the chemical philosophers of Europe. The hypothesis of Lavoisier, that combustion was merely the combination of oxygen with a basis, had become as favourite an idol with the learned as the previous hypothesis of Stahl, that one phlogistic principle pervaded all combustible bodies, which was either evolved in heat and light, or quietly transferred to an incombustible, imparting that inflammability to the new substance, which its former companion had secretly lost. Stahl's idea of combustion is the more comprehensive, and *may* still be true; Lavoisier's, as a general proposition, is certainly false.

In 1812 Sir H. Davy published his Elements of Chemical Philosophy, containing a systematic account of his new doctrines concerning the combination of simple bodies. Chlorine is there placed in the same rank with oxygen, and finally removed from the class of acids. In 1813, M. Thenard published the first volume of his *Traité de Chimie Elementaire Theorique et Pratique*. This distinguished chemist, the fellow-labourer of M. Gay Lussac, in those able researches on the alkalis and oxymuriatic acid, which form the distinguished rivalry of the French school to the brilliant career of Sir H. Davy, states at page 584 of the above volume, the composition of oxymuriatic acid as follows: "*Composition.* The oxygenated muriatic gas contains the half of its volume of oxygen gas, not including that which we may suppose in muriatic acid. It thence follows, that it is formed of 1.9183 of muriatic acid, and 0.5517 of oxygen; for the specific gravity of oxygenated muriatic gas is 2.47, and that of oxygen gas 1.1034."—"M. Chenevix first determined the proportion of its constituent principles. MM. Gay Lussac and Thenard determined it more exactly, and showed that we could not decompose the oxygenated muriatic gas, but by putting it in contact with a body capable of uniting with the *two* elements of this gas, or with muriatic acid. They announced at the same time, that they could explain all the phenomena which it presents, by considering it as a simple or as a compound body. However, this last opinion appeared more probable to them. M. Davy, on the contrary, embraced the first, admitted it exclusively, and sought to fortify it by experiments which are peculiar to him. P. 585.

In the second volume of M. Thenard's work, published in 1814, he explains the mutual action of chlorine and ammonia gases, solely on the oxygenous theory. "On peut démontrer par ce dernier procédé, que le gas muriatique oxigéné doit contenir la moitié de son volume d'oxigène, uni à l'acide muriatique." P. 147.—In the 4th volume, which appeared in 1816, we find the following passages: "*Oxygenated muriatic gas.* Oxygenated muriatic gas, in combining with the metals, gives rise to the neutral muriates. Now, 107.6 of oxide of silver, contain 7.6 of oxygen, and absorb 26.4 of muriatic acid, to pass to the state of neutral muriate. Of consequence, 348 of this last acid supposed dry, and 100 of oxygen, form this gas. But the sp. gr. of oxygen is 1.1034, and that of oxygenated muriatic gas is 2.47; hence, this contains the half of its volume of oxygen." P. 52.

The force of Sir H. Davy's demonstrations, pressing for six years on the public mind of the French philosophers, now begins to transpire in a note to the above passage.—"We reason here," says M. Thenard, "obviously on the hypothesis, which consists in regarding oxygenated muriatic gas as a compound body." This pressure of public opinion becomes conspicuous at the end of the volume. Among the additions, we have the following decisive evidence of the lingering attachment to the old theory of Lavoisier and Berthollet.—"A pretty considerable number of persons who have subscribed for this work, desiring a detailed explanation of the phenomena which oxygenated muriatic gas presents, on the supposition that this gas is a simple body, we are now going to explain these phenomena, on this supposition, by considering them attentively. The oxygenated muriatic gas will take the name of *chlorine;* its combinations with phosphorus, sulphur, azote, metals, will be called *chlorures;* the muriatic acid, which results from equal parts in volume of hydrogen and oxygenated muriatic gases, will be *hydrochloric acid;* the superoxygenated muriatic acid will be *chlorous acid;* and the hyperoxygenated muriatic, *chloric acid;* the first, comparable to the hydriodic acid, and the last to the iodic acid." In fact, therefore, we evidently see, that so far from the *chloridic* theory originating in France, as has been more than insinuated, it was only the researches on iodine, so admirably conducted by M. Gay Lussac, that, by their auxiliary attack on the oxygen hypothesis, eventually opened the minds of its adherents to the evidence long ago advanced by Sir Humphrey Davy. It will be peculiarly instructive, to give a general outline of that evidence, which has been mutilated in some systematic works on chemistry, or frittered away into fragments.

Sir H. Davy subjected oxymuriatic gas to the action of many simple combustibles, as well as metals, and from the compounds formed, endeavoured to eliminate oxygen, by the most energetic powers of affinity and voltaic electricity, but without success, as the following abstract will show.

If oxymuriatic acid gas be introduced into a vessel exhausted of air, containing tin, and the tin be gently heated, and the gas in sufficient quantity, the tin and the gas disappear, and a limpid fluid, precisely the same as Libavius's liquor, is formed: If this substance is a combination of muriatic acid and oxide of tin, oxide of tin ought to be separated from it by means of ammonia. He admitted ammoniacal gas over mercury to a small quantity of the liquor of Libavius; it was absorbed with great heat, and no gas was generated; a solid result was obtained, which was of a dull white colour: some of it was heated, to ascertain if it contained oxide of tin; but the whole volatilized, producing dense pungent fumes.

Another experiment of the same kind, made with great care, and in which the ammonia was used in great excess, proved that the liquor of Libavius cannot be decompounded by ammonia; but that it forms a new combination with this substance.

He made a considerable quantity of the solid compound of oxymuriatic acid and phosphorus by combustion, and saturated it with ammonia, by heating it in a proper receiver filled with ammoniacal gas, on which it acted with great energy, producing much heat; and they formed a white opaque powder. Supposing that this substance was composed of the dry muriates and phosphates of ammonia; as muriate of ammonia is very volatile, and as ammonia is driven off from phosphoric acid by a heat below redness, he conceived that, by igniting the product obtained, he should procure phosphoric acid; he therefore introduced some of the powder into a tube of green glass, and heated it to redness, out of the contact of air, by a spirit lamp; but found to his great surprise, that it was not at all volatile, nor decomposable at this degree of heat, and that it gave off no gaseous matter.

The circumstance, that a substance composed principally of oxymuriatic acid, and ammonia, should resist decomposition or change at so high a temperature, induced him to pay particular attention to the properties of this new body.

It has been said, and taken for granted by many chemists, that when oxymuriatic acid and ammonia act upon each other, water is formed: he several times made the experiment, and was convinced that this is not the case.

He mixed together sulphuretted hydrogen in a high degree of purity, and oxymuriatic acid gas, both dried, in equal volumes. In this instance the condensation was not $\frac{1}{40}$; sulphur, which seemed to contain a little oxymuriatic acid, was formed on the sides of the vessel; no vapour was deposited, and the residual gas contained about $\frac{12}{20}$ of muriatic acid gas, and the remainder was inflammable.

When oxymuriatic acid is acted upon by nearly an equal volume of hydrogen, a combination takes place between them, and muriatic acid gas results. When muriatic acid gas is acted on by mercury, or any other metal, the oxymuriatic acid is attracted from the hydrogen by the stronger affinity of the metal, and an oxymuriate, exactly similar to that formed by combustion, is produced.

The action of water upon those compounds which have been usually considered as muriates, or as dry muriates, but which are properly combinations of oxymuriatic acid with inflammable bases, may be easily explained, according to these views of the subject. When water is added in certain quantities to Libavius's liquor, a solid crystallized mass is obtained from which oxide of tin and muriate of ammonia can be procured by ammonia. In this case, oxygen may be conceived to be supplied to the tin, and hydrogen to the oxymuriatic acid.

The compound formed by burning phosphorus in oxymuriatic acid is in a similar relation to water. If that substance be added to it, it is resolved into two powerful acids; oxygen, it may be supposed, is furnished to the phosphorus to form phosphoric acid, hydrogen to the oxymuriatic acid to form common muriatic acid gas.

He caused strong explosions from an electrical jar to pass through oxymuriatic gas, by means of points of platina, for several hours in succession; but it seemed not to undergo the slightest change.

He electrized the oxymuriates of phosphorus and sulphur for some hours, by the power of the voltaic apparatus of 1000 double plates. No gas separated, but a minute quantity of hydrogen, which he was inclined to attribute to the presence of moisture in the apparatus employed; for he once obtained hydrogen from Libavius's liquor by a similar operation. But he ascertained that this was owing to the decomposition of water adhering to the mercury: and in some late experiments made with 2000 double plates, in which the discharge was from platina wires, and in which the mercury used for confining the liquor was carefully boiled, there was no production of any permanent elastic matter.

Few substances, perhaps, have less claim to be considered as acid than oxymuriatic acid. As yet we have no right to say that it has been decompounded; and as its tendency of combination is with pure inflammable matters, it may possibly belong to the same class of bodies as oxygen.

May it not in fact be a *peculiar* acidifying and dissolving principle, forming compounds with combustible bodies, analogous to acids containing oxygen or oxides, in their properties and powers of combination; but differing from them, it being for the most part decomposable by water? On this idea, muriatic acid may be considered as having hydrogen for its basis, and oxymuriatic acid for its acidifying principle; and the phosphoric sublimate as having phosphorus for its basis, and oxymuriatic acid for its acidifying matter; and Libavius's liquor, and the compounds of arsenic with oxymuriatic acid, may be regarded as analogous bodies. The combinations of oxymuriatic acid with lead, silver, mercury, potassium, and sodium, in this view, would be considered as a class of bodies related more to oxides than acids, in their powers of attraction.—*Bak. Lec.* 1809.

On the Combination of the Common Metals with Oxygen and Oxymuriatic Gas.

Sir H. used in all cases small retorts of green glass, containing from three to six cubical inches, furnished with stop-cocks. The metallic substances were introduced, the retort exhausted and filled with the gas to be acted upon, heat was applied by means of a spirit lamp, and after cooling, the results were examined, and the residual gas analyzed.

All the metals that he tried, except silver, lead, nickel, cobalt, and gold, when heated, burnt in the oxymuriatic gas, and the volatile metals with flame. Arsenic, antimony, tellurium, and zinc, with a white flame, mercury with a red flame. Tin became ignited to whiteness, and iron and copper to redness; tungsten and manganese to dull redness; platina was scarcely acted upon at the heat of fusion of the glass.

The product from mercury was corrosive sublimate. That from zinc was similar in colour to that from antimony, but was much less volatile.

Silver and lead produced horn-silver and horn-lead; and bismuth, butter of bismuth.

In acting upon metallic oxides by oxymuriatic gas, he found that those of lead, silver, tin, copper, antimony, bismuth, and tellurium, were decomposed in a heat below redness, but the oxides of the volatile metals more readily than those of the fixed ones. The oxides of cobalt and nickel were scarcely acted upon at a dull red heat. The red oxide of iron was not affected at a strong red heat, whilst the black oxide was readily decomposed at a much lower temperature; arsenical acid underwent no change at the greatest heat that could be given it in the glass retort, whilst the white oxide readily decomposed.

In cases where oxygen was given off, it was found exactly the same in quantity as that which had been absorbed by the metal. Thus two grains of red oxide of mercury absorbed $\frac{9}{10}$ of a cubical inch of oxymuriatic gas, and afforded 0.45 of oxygen. Two grains of dark olive oxide from calomel decomposed by potash, absorbed about $\frac{94}{100}$ of oxymuriatic gas, and afforded $\frac{24}{100}$ of oxygen, and corrosive sublimate was produced in both cases.

In the decomposition of the white oxide of zinc, oxygen was expelled exactly equal to half the volume of the oxymuriatic acid absorbed. In the case of the decomposition of the black oxide of iron, and the white oxide of arsenic, the changes that occurred were of a very beautiful kind; no oxygen was given off in either case, but butter of arsenic and arsenical acid formed in one instance, and the ferruginous sublimate and red oxide of iron in the other.

General Conclusions and Observations, illustrated by Experiments.

Oxymuriatic gas combines with inflammable bodies, to form simple binary compounds; and in these cases, when it acts upon oxides, it either produces the expulsion of their oxygen, or causes it to enter into new combinations.

If it be said that the oxygen arises from the decomposition of the oxymuriatic gas, and not from the oxides, it may be asked, why it is always the quantity contained in the oxide? and why in some cases, as those of the peroxides of potassium and sodium, it bears no relation to the quantity of gas?

If there existed any acid matter in oxymuriatic gas, combined with oxygen, it ought to be exhibited in the fluid compound of one proportion of phosphorus, and two of oxymuriatic gas; for this, on such an assumption, should consist of muriatic acid (on the old hypothesis, free from water) and phosphorous acid; but this substance has no effect on litmus paper, and does not act under common circumstances on fixed alkaline bases, such as dry lime or magnesia. Oxymuriatic gas, like oxygen, must be combined in large quantity with peculiar inflammable matter, to form acid matter. In its union with hydrogen, it instantly reddens the driest litmus paper, though a gaseous body. Contrary to acids, it expels oxygen from protoxides, and combines with peroxides.

When potassium is burnt in oxymuriatic gas, a dry compound is obtained. If potassium combined with oxygen is employed, the whole of the oxygen is expelled, and the same compound formed. It is contrary to sound logic to say, that this exact quantity of oxygen is given off from a body not known to be compound, when we are certain of its existence in another; and all the cases are parallel.

Scheele explained the bleaching powers of the oxymuriatic gas, by supposing that it destroyed colours by combining with phlogiston. Berthollet considered it as acting by supplying oxygen. He made an experiment, which seems to prove that the pure gas is incapable of altering vegetable colours, and that its operation in bleaching depends entirely upon its property of decomposing water, and liberating its oxygen.

He filled a glass globe, containing dry powdered muriate of lime, with oxymuriatic gas. He introduced some dry paper tinged with litmus that had been just heated, into another globe containing dry muriate of lime; after some time this globe was exhausted, and then connected with the globe containing the oxymuriatic gas, and by an appropriate set of stop-cocks, the paper was exposed to the action of the gas. No change of colour took place, and after two days there was scarcely a perceptible alteration.

Some similar paper dried, introduced into gas that had not been exposed to muriate of lime, was instantly rendered white.

It is generally stated in chemical books, that oxymuriatic gas is capable of being condensed and crystallized at a low temperature. He found by several experiments that this is not the case. The solution of oxymuriatic gas in water freezes more readily than pure water, but the pure gas dried by muriate of lime undergoes no change whatever, at a temperature of 40 below 0° of Fahrenheit. The mistake seems to have arisen from the exposure of the gas to cold in bottles containing moisture.

He attempted to decompose boracic and phosphoric acids by oxymuriatic gas, but without success; from which it seems probable, that the attractions of boracium and phosphorus for oxygen are stronger than for oxymuriatic gas. And from the experiments already detailed, iron and arsenic are analogous in this respect, and probably some other metals.

Potassium, sodium, calcium, strontium, barium, zinc, mercury, tin, lead, and probably silver, antimony, and gold, seem to have a stronger attraction for oxymuriatic gas than for oxygen.

"To call a body which is not known to contain oxygen, and which cannot contain muriatic acid, oxymuriatic acid, is contrary to the principles of that nomenclature in which it is adopted; and an alteration of it seems necessary to assist the progress of discussion, and to diffuse just ideas on the subject. If the great discoverer of this substance had signified it by any simple name, it would have been proper to have recurred to it; but dephlogisticated marine acid is a term which can hardly be adopted in the present advanced era of the science.

"After consulting some of the most eminent chemical philosophers in this country, it has been judged most proper to suggest a name founded upon one of its obvious and characteriatic properties—its colour, and to call it *chlorine* or *chloric* gas.

"Should it hereafter be discovered to be compound, and even to contain oxygen, this name can imply no error, and cannot necessarily require a change.

"Most of the salts which have been called muriates, are not known to contain any muriatic acid, or any oxygen. Thus Libavius's liquor, though converted into a muriate by water, contains only tin and oxymuriatic gas, and horn-silver seems incapable of being converted into a true muriate."—*Bak. Lec.* 1811.

We shall now exhibit a summary view of the preparation and properties of chlorine.

Mix in a mortar 3 parts of common salt and 1 of black oxide of manganese. Introduce them into a glass retort, and add 2 parts of sulphuric acid. Gas will issue, which must be collected in the water-pneumatic trough. A gentle heat will favour its extrication. In practice, the above pasty-consistenced mixture is apt to boil over into the neck. A mixture of liquid muriatic acid and manganese is therefore more convenient for the production of chlorine. A very slight heat is adequate to its expulsion from the retort. Instead of manganese, red oxide of mercury, or puce-coloured oxide of lead, may be employed.

This gas, as we have already remarked, is of a greenish-yellow colour, easily recognized by day-light, but scarcely distinguishable by that of candles. Its odour and taste are disagreeable, strong, and so characteristic, that it is impossible to mistake it for any other gas. When we breathe it, even much diluted with air, it occasions a sense of strangulation, constriction of the *thorax*, and a copious discharge from the nostrils. If respired in larger quantity, it excites violent coughing, with spitting of blood, and would speedily destroy the individual, amid violent distress. Its specific gravity is 2·5. This is better inferred from the specific gravities of hydrogen and muriatic acid gases, than from the direct weight of chlorine, from the impossibility of confining it over mercury. One volume of hydrogen, added to one of chlorine, form two of the acid gas. Hence, if from twice the specific gravity of muriatic gas $= 2.5694$, we subtract that of hydrogen $= 0.0694$, the difference 2.5 is the specific gravity of chlorine. 100 cubic inches at mean pressure and temperature weigh 75¼ grains. See GAS.

Sir H. Davy having suggested (*Phil. Trans.* 1823) to Mr. Faraday to expose the crystalline hydrate of chlorine (see *infra*) to heat under pressure, the following experiments were commenced at his request. Some hydrate of chlorine, dried by pressure on bibulous paper, was introduced into a sealed glass tube, the upper end of which was then hermetically closed. Being placed in water at 60° no change was perceived; but when put into water at 100° the hydrate fused, the tube became filled with a bright yellow atmosphere, and on examination it was found to contain two fluid substances; the one, about three-fourths of the whole, was of a faint yellow colour, having very much the appearance of water; the remaining fourth was a heavy bright yellow fluid, lying at the bottom of the former, without any apparent tendency to mix with it. As the tube cooled, the yellow atmosphere condensed into more of the yellow fluid, which floated in a film on the pale fluid, looking very like chloride of nitrogen. He afterwards succeeded in distilling the yellow fluid to one end of the tube, and so separated it from the remaining portion. When the tube was cut in the middle the parts flew asunder, and a powerful atmosphere of chlorine exhaled. Subsequently, by a condensing syringe, he converted chlorine dried over sulphuric acid into the same yellow liquid. Since then, M. Bussy has liquefied chlorine, by cooling the vessel containing it, with his liquid sulphurous acid.

In its perfectly dry state, the gas has no effect on dry vegetable colours. With the aid of a little moisture, it bleaches them into a yellowish-white. Scheele first remarked this bleaching property; Berthollet applied it to the art of bleaching in France; and from him Mr. Watt introduced its use into Great Britain.

If a lighted wax taper be immersed rapidly into this gas, it consumes very fast, with a dull reddish flame, and much smoke. The taper will not burn at the surface of the gas. Hence, if slowly introduced, it is apt to be extinguished. The alkaline metals, as well as copper, tin, arsenic, zinc, antimony, in fine laminæ or filings, spontaneously burn in chlorine. Metallic chlorides result. Phosphorus also takes fire at ordinary temperatures, and is converted into a chloride. Sulphur may be melted in the gas without taking fire. It forms a liquid chloride, of a reddish colour. When dry, it is not altered by any change of temperature. Enclosed in a phial with a little moisture, it concretes into crystalline needles, at 40° Fahr.

According to M. Thenard, water condenses at the temperature of 68° Fahr., and at 29.92 barom. 1½ times its volume of chlorine, and forms *aqueous* chlorine, formerly called liquid oxymuriatic acid. This combination is best made in the second bottle of a Woolfe's apparatus, the first being charged with a little water, to intercept the muriatic acid gas, while the third bottle may contain potash-water, or milk of lime, to condense the superfluous gas. M. Thenard says, that a kilogramme of salt is sufficient for saturating from 10 to 12 litres of water. These measures correspond to 2⅕ lbs. avoirdupois, and to from 21 to 25 pints English. There is an ingenious apparatus for making aqueous chlorine, described in Berthollet's Elements of Dyeing, vol. i.; which, however, the happy substitution of slaked lime for water, by Mr. Charles Tennent of Glasgow, has superseded, for the purposes of manufacture. It congeals by cold at 40° Fahr. and affords crystallized plates, of a deep yellow, containing a less proportion of water than the liquid combination. Hence, when chlorine is passed into water at temperatures under 40°, the liquid finally becomes a concrete mass, which at a gentle heat liquefies with effervescence, from the escape of the excess of chlorine.

The hydrate of chlorine may be obtained, well crystallized, by introducing into a clean bottle of the gas a little water, but not sufficient to convert the whole into hydrate, and then placing the bottle in a temperature somewhat below 32° Fahr. for a few days, in a dark place. The hydrate is produced in a crust, or in dendritical crystals, but, being left to itself, will in a few days sublime from one part of the bottle to another, in the manner of camphor, forming brilliant and comparatively large crystals, which when most perfect are acute flattened octohedra. These crystals consist in 100 parts of 27.7 chlorine + 72.3 water; which accords with 10 atoms of water to 1 of chlorine.—*Mr. Faraday, Journal of Science*, xv. 71.

When steam and chlorine are passed together through a red-hot porcelain tube, they are converted into muriatic acid and oxygen. A like result is obtained by exposing aqueous chlorine to the solar rays; with this difference, that a little chloric acid is formed. Hence, aqueous chlorine should be kept in a dark place. Aqueous chlorine attacks almost all the metals at an ordinary temperature, forming muriates or chlorides, and heat is evolved. It has the smell, taste, and colour of chlorine; and acts, like it, on vegetable and animal colours. Its taste is somewhat astringent, but not in the least degree acidulous.

When we put in a perfectly dark place, at the ordinary temperature, a mixture of chlorine and hydrogen, it experiences no kind of alteration, even in the space of a great many days. But if, at the same low temperature, we expose the mixture to the diffuse light of day, by degrees the two gases enter into chemical combination, and form muriatic acid gas. There is no change in the *volume* of the mixture, but the change of its *nature* may be proved, by its rapid absorbability by water, its not exploding by the lighted taper, and the disappearance of the chlorine hue. To produce the complete discoloration, we must expose the mixture finally for a few minutes to the sunbeam. If exposed at first to this intensity of light, it explodes with great violence, and instantly forms muriatic acid gas. The same explosive combination is produced by the electric spark and the lighted taper. M. Thenard says, a heat of 392° is sufficient to cause the explosion. The proper proportion is an equal volume of each gas. Chlorine and nitrogen combine into a remarkable detonating compound, by exposing the former gas to a solution of an ammoniacal salt. See NITROGEN. Chlorine is the most powerful agent for destroying contagious *miasmata*. The disinfecting phials of Morveau evolve this gas.

Dr. Brown has recently employed chlorine in solution, in cases of the scarlet fever, with the utmost success. From a tea spoonful to a table spoonful is given every two or three hours, without the addition of any other substance. The solution should be fresh made, and swallowed quickly to avoid coughing; in the sore throat sometimes accompanying the fever, it is more easily swallowed than mucilaginous drinks. As the disease declines, the quantity of medicine is diminished: the whole quantity in the cases of children has never exceeded two ounces, and in adults five ounces. For its anticontagious powers, see LIME (CHLORIDE OF). See CHLOROUS OXIDE.

CHLORITE is a mineral usually friable or very easy to pulverize, composed of a multitude of little spangles, or shining small grains, falling to powder under the pressure of the fingers. There are four sub-species. 1. *Chlorite earth*. In green, glimmering, and somewhat pearly scales, with a shining green streak. It adheres to the skin, and has a greasy feel. Spec. grav. 2.6. It consists of 50 silica, 26 alumina, 1.5 lime, 5 oxide of iron, 17.5 potash. This mineral is found chiefly in clay-slate, in Germany and Switzerland. At Altenberg, in Saxony, it is intermingled with sulphurets of iron and arsenic; and amphibole in mass. 2. *Common chlorite*. A massive mineral of a blackish-green colour, a shining lustre, and a foliated fracture passing into earthy. Streak is lighter green; it is soft, opaque, easily cut and broken, and feels greasy. Spec. grav. 2.83. Its constituents are 26 silica, 18.5 alumina, 8 magnesia, 43 oxide of iron, and 2 muriate of potash. 3. *Chlorite slate*. A massive, blackish-green mineral, with resinous lustre, and curve slaty or scaly-foliated fracture. Double cleavage. Easily cut. Feels somewhat greasy. Spec. grav. 2.82. It occurs particularly along with clay-slate, and is found in Corsica, Fahlun in Sweden, and Norway. 4. *Foliated chlorite*. Colour between mountain and blackish-green. Massive; but commonly crystallized in six-sided tables, in cylinders terminated by two cones, and in double cones with the bases joined. Surface streaked. Lustre shining pearly; foliated fracture, translucent on the edges; soft, sectile, and folia usually flexible. Feels rather greasy. Spec. grav. 2.82. It is found at St. Gothard, in Switzerland, and in the island of Java. Its constituents are 35 silica, 18 alumina, 29.9 magnesia, 9.7 oxide of iron, 2.7 water.

CHLOROPHANE. A violet *fluor spar*, found in Siberia.

CHLORIDES. Compounds of chlorine with bases. See the respective bases.

CHLORIDE OF CARBON. See CARBON.

CHLORO-CARBONOUS ACID. The term chloro-carbonic which has been given to this compound is incorrect, leading to the belief of its being a compound of chlorine and acidified charcoal, instead of being a compound of chlorine and the protoxide of charcoal. Chlorine has no immediate action on carbonic oxide, when they are exposed to each other in common day-light over mercury; not even when the electric spark is passed through them. Experiments made by Dr. John Davy, in the presence of his brother Sir H. Davy, prove that they combine rapidly when exposed to the direct solar beams, and one volume of each is condensed into one volume of the compound. The resulting gas possesses very curious properties, approaching to those of an acid. From the peculiar potency of the sunbeam in effecting this combination, Dr. Davy called it *phosgene gas*. The constituent gases, dried over muriate of lime, ought to be introduced from separate reservoirs into an exhausted globe, perfectly dry, and exposed for fifteen minutes to bright sunshine, or for twelve hours to day-light. The colour of the chlorine disappears, and on opening the stopcock belonging to the globe under mercury recently boiled, an absorption of one-half the gaseous volume is indicated. The resulting gas possesses properties perfectly distinct from those belonging to either carbonic oxide or chlorine.

It does not fume in the atmosphere. Its odour is different from that of chlorine, something like that which might be imagined to result from the smell of chlorine combined with that of ammonia. It is in fact more intolerable and suffocating than chlorine itself, and affects the eyes in a peculiar manner, producing a rapid flow of tears, and occasioning painful sensations.

It reddens dry litmus paper, and condenses four volumes of ammonia into a white salt, while heat is evolved. This ammoniacal compound is neutral, has no odour, but a pungent saline taste; is deliquescent, decomposable by the liquid mineral acids, dissolves without effervescing in vinegar, and sublimes unaltered in muriatic, carbonic, and sulphurous acid gases. Sulphuric acid resolves it into carbonic and muriatic acids, in the proportion of two in volume of the latter, and one of the former. Tin, zinc, antimony, and arsenic, heated in chloro-carbonous acid, abstract the chlorine, and leave the carbonic oxide expanded to its original volume. Neither ignition nor explosion takes place, though the action of the metals is rapid. Potassium acting on the compound gas produces a solid chloride and charcoal. White oxide of zinc, with chloro-carbonous acid, gives a metallic chloride, and carbonic acid. Neither sulphur, phosphorus, oxygen, nor hydrogen, though aided by heat, produces any change on the acid gas. But oxygen and hydrogen together, in due proportions, explode in it; or mere exposure to water converts it into muriatic and carbonic acid gases.

From its completely neutralizing ammonia, which carbonic acid does not; from its separating carbonic acid from the subcarbonate of this alkali, while itself it not separable by the acid gases or acetic acid, and its reddening vegetable blues, there can be no hesitation in pronouncing the chloro-carbonous compound to be an acid. Its saturating powers indeed surpass every other substance. None condenses so large a proportion of ammonia.

One measure of alcohol condenses twelve of chloro-carbonous gas without decomposing it; and acquires the peculiar odour and power of affecting the eyes.

To prepare the gas in a pure state, a good air-pump is required, perfectly tight stop-cocks, dry gases, and dry vessels. Its specific gravity may be inferred from the specific gravities of its constituents, of which it is the sum. Hence $2.5 + 0.9722 = 3.4722$, is the specific gravity of chloro-carbonous gas; and 100 cubic inches weigh 105.9 grains. It appears that when hydrogen, carbonic oxide, and chlorine, mixed in equal volumes, are exposed to light, muriatic and chloro-carbonous acids are formed, in equal proportions, indicating an equality of affinity.

The paper in the Phil. Trans. for 1812, from which the preceding facts are taken, does honour to the school of Sir H. Davy. MM. Gay Lussac and Thenard, as well as Dr. Murray, made controversial investigations on the subject at the same time, but without success. M. Thenard has, however, recognized its distinct existence and properties, by the name of *carbo-muriatic* acid, in the 2d volume of his System, published in 1814, where he considers it as a compound of muriatic and carbonic acids, resulting from the mutual actions of the *oxygenated muriatic acid* and carbonic oxide.

CHLOROPAL. A mineral of which there are two varieties, the conchoidal, and the earthy. The conchoidal has a pistachio green colour, opaque, specific gravity 2. It breaks readily into parallelopipeds. It consists of silica 46; oxide of iron 35.3; magnesia 2; alumina 1.0; water 18; with traces of potash and manganese. It is found accompanying copal, not far from Unghwar in the comitate of the same name.

CHLOROPHŒITE. A mineral of a green colour when newly broken, but soon becoming black. It is scratched by a quill. Brittle. Sp. grav. 2.02. Not affected by the blowpipe. It is found imbedded in the amygdaloids of the cliff of Scuirmore, in the isle of Rum, and also in Fife, in nodules generally round, from the size of a radish seed, to that of a pea. *Dr. Macculloch.*

CHLOROUS and CHLORIC OXIDES, or the protoxide and deutoxide of chlorine.

Both of these interesting gaseous compounds were discovered by Sir H. Davy.

1st, The experiments which led him to the knowledge of the first were instituted in consequence of the difference he had observed between the properties of chlorine, prepared in different modes. The paper describing the production and properties of the chlorous oxide was published in the first part of the Phil. Trans. for 1811. To prepare it, we put chlorate of potash into a small retort, and pour in twice as much muriatic acid as will cover it, diluted with an equal volume of water. By the application of a gentle heat, the gas is evolved. It must be collected over mercury.

Its tint is much more lively, and more yellow than chlorine, and hence its illustrious discoverer named it *euchlorine*. Its smell is peculiar, and approaches to that of burnt sugar. It is not respirable. It is soluble in water, to which it gives a lemon colour. Water absorbs 8 or 10 times its volume of this gas. Its specific gravity is to that of common air nearly as 2.40 to 1; for 100 cubic inches weigh, according to Sir H. Davy, between 74 and 75 grains. If the compound gas result from 4 volumes of chlorine + 2 of oxygen, weighing 12.1154, which undergo a condensation of one-sixth, then the specific gravity comes out 2.423, in accordance with Sir H. Davy's experiments. He found that 50 measures detonated in a glass tube over pure mercury, lost their brilliant colour, and became 60 measures, of which 40 were chlorine and 20 oxygen.

This gas must be collected and examined with much prudence, and in very small quantities. A gentle heat, even that of the hand, will cause its explosion, with such force as to burst thin glass. From this facility of decomposition, it is not easy to ascertain the action of combustible bodies upon it. None of the metals that burn in chlorine act upon this gas at common temperatures; but when the oxygen is separated, they then inflame in the chlorine. This may be readily exhibited, by first introducing into the protoxide a little Dutch foil, which will not be even tarnished; but on applying a heated glass tube to the gas in the neck of the bottle, decomposition instantly takes place, and the foil burns with brilliancy. When already in chemical union, therefore, chlorine has a stronger attraction for oxygen than for metals; but when insulated, its affinity for the latter is predominant. Protoxide of chlorine has no action on mercury, but chlorine is rapidly condensed by this metal into calomel. Thus the two gases may be completely separated. When phosphorus is introduced into the protoxide, it instantly burns, as it would do in a mixture of two volumes of chlorine and one of oxygen; and a chloride and acid of phosphorus result. Lighted taper and burning sulphur likewise instantly decompose it. When the protoxide freed from water is made to act on dry vegetable colours, it gradually destroys them, but first gives to the blues a tint of red; from which, from its absorbability by water, and the strongly acrid taste of the solution approaching to sour, it may be considered as approximating to an acid in its nature. Since 2 volumes of chlorine weigh (2×2.5) 5, and 1 of oxygen 1.1111; we have $4.5 + 1 = 5.5$ for the prime equivalent of chlorous oxide on the oxygen scale. The proportion by weight in 100 parts is 81.65 chlorine + 18.35 oxygen.

2d, *Deutoxide of Chlorine*, or *Chloric Oxide*. "On Thursday the 4th May, a paper by Sir H. Davy was read at the Royal Society, on the action of acids on hyper-oxymuriate of potash. When sulphuric acid is poured upon this salt in a wine-glass, very little effervescence takes place, but the acid gradually acquires an orange colour, and a dense yellow vapour, of a peculiar and not disagreeable smell, floats on the surface. These phenomena led the author to believe, that the substance extricated from the salt is held in solution by the acid. After various unsuccessful attempts to obtain this substance in a separate state, he at last succeeded by the following method: About 60 grains of the salt are triturated with a little sulphuric acid, just sufficient to convert them into a very solid paste. This is put into a retort, which is heated by means of hot water. The water must never be allowed to become boiling hot, for fear of explosion. The heat drives off the new gas, which may be received over mercury. This new gas has a much more intense colour than euchlorine. It does not act on mercury. Water absorbs more of it than of euchlorine. Its taste is astringent. It destroys vegetable blues without reddening them. When phosphorus is introduced into it, an explosion takes place. When heat is applied, the gas explodes with more violence, and producing more light than euchlorine. When thus exploded, two measures of it are converted into nearly three measures, which consist of a mixture of one measure chlorine, and two measures oxygen. Hence, it is composed of one atom chlorine and four atoms oxygen."

Deutoxide of chlorine has a peculiar aromatic odour, unmixed with any smell of chlorine. A little chlorine is always absorbed by the mercury during the explosion of the gas. Hence the small deficiency of the resulting measure is accounted for. At common temperatures none of the simple combustibles which Sir H. Davy tried, decompose the gas, except phosphorus. The taste of the aqueous solution is extremely astringent and corroding, leaving for a long while a very disagreeable sensation. The action of liquid nitric acid on the chlorate of potash affords the same gas, and a much larger quantity of this acid may be safely employed than of the sulphuric. But as the gas must be procured by solution of the salt, it is always mixed with about one-fifth of oxygen.

Since two measures of this gas, at 212°, explode and form three measures of mingled gases, of which two are oxygen and one chlorine; its composition by weight is

Oxygen,	2.2222	4 primes,	4.00	47
Chlorine,	2.5	1 do.	4.5	53
			8.5	100

Its specific gravity is 2.361; and hence 100 cubic inches of it weigh about 77 grains.

CHLOROPHILE. The name lately given by MM. Pelletier and Caventou to the green matter of the leaves of plants. They obtained it by pressing, and then washing in water, the substance of many leaves, and afterwards treating it with alcohol. A matter was dissolved, which, when separated by evaporation, and purified by washing in hot water, appeared as a deep green resinous substance. It dissolves entirely in alcohol, ether, oils, or alkalis; it is not altered by exposure to air: it is softened by heat, but does not melt; it burns with flame, and leaves a bulky coal. Hot water slightly dissolves it. Acetic acid is the only acid that dissolves it in great quantity. If an earthy or metallic salt be mixed with the alcoholic solution, and then alkali or alkaline subcarbonate be added, the oxide or earth is thrown down in combination with much of the green substance, forming a lake. These lakes appear moderately permanent when exposed to the air. It is supposed to be a peculiar proximate principle.

The above learned term should be spelled with a *y*, chlorophyle, to signify the green of leaf, or leaf-green: chlorophile, with an *i*, has a different etymology, and a different meaning. It signifies *fond* of green.

CHOLESTERINE. The name given by M. Chevreul to the pearly substance of human biliary calculi. It consists of 72 carbon, 6.66 oxygen, and 21.33 hydrogen, by Berard.

M. Chevreul has lately extracted cholesterine from human bile. The bile, after being diluted, filtered, and concentrated, was precipitated by alcohol; the alcoholic extract was acted upon by ether, and the latter solution left to crystallize spontaneously; a substance separated, which, when purified, was neither acid nor alkaline to vegetable colours, which like cholesterine crystallized, either when fused and cooled, or when dissolved in alcohol or ether. It required about 212° for its fusion, was not saponified by being boiled for 24 hours in solution of potash; in contact with sulphuric acid, it instantly became of an orange-red colour, and with nitric acid comported itself like cholesterine. The same substance was also obtained by him from the bile of a bear and a pig.

CHOLESTERIC ACID. See ACID (CHOLESTERIC).

CHROMIUM. This metal may be extracted either from the native chromate of lead or of iron. The latter being cheapest and most abundant, is usually employed.

The brown chromite of iron is not acted upon by nitric acid, but most readily by nitrate of potash, with the aid of a red heat. A chromate of potash, soluble in water, is thus formed. The iron oxide thrown out of combination may be removed from the residual part of the ore by a short digestion in dilute muriatic acid. A second fusion with ¼ of nitre, will give rise to a new portion of chromate of potash. Having decomposed the whole of the ore, we saturate the alkaline excess with nitric acid, evaporate and crystallize. The pure crystals, dissolved in water, are to be added to a solution of neutral nitrate of mercury; whence, by complex affinity, red chromate of mercury precipitates. Moderate ignition expels the mercury from the chromate, and the remaining chromic acid may be reduced to the metallic state, by being exposed in contact of the charcoal from sugar, to a violent heat.

Chromium thus procured is a porous mass of agglutinated grains. It is very brittle, and of a greyish-white, intermediate between tin and steel. It is sometimes obtained in needleform crystals, which cross each other in all directions. Its sp. gravity is 5.9. It is susceptible of a feeble magnetism. It resists all the acids except nitromuriatic, which, at a boiling heat, oxidizes it and forms a muriate. M. Thenard describes only one oxide of chromium; but there are probably two, besides the acid already described.

1. The protoxide is green, infusible, indecomposable by heat, reducible by voltaic electricity, and not acted on by oxygen or air. When heated to dull redness with the half of its weight of potassium or sodium, it forms a brown matter, which, cooled and exposed to the air, burns with flame, and is transformed into chromate of potash or soda, of a canary-yellow colour. It is this oxide which is obtained by calcining the chromate of mercury in a small earthen retort for about ¾ of an hour. The beak of the retort is to be surrounded with a tube of wet linen, and plunged into water, to facilitate the condensation of the mercury. The oxide, newly precipitated from acids, has a dark green colour, and is easily redissolved; but exposure to a dull red heat ignites it, and renders it denser, insoluble, and of a light green colour. This change arises solely from the closer aggregation of the particles, for the weight is not altered.

2. The deutoxide is procured by exposing the protonitrate to heat, till the fumes of nitrous gas cease to issue. A brilliant brown

powder, insoluble in acids, and scarcely soluble in alkalis, remains. Muriatic acid digested on it exhales chlorine, showing the increased proportion of oxygen in this oxide.

3. The tritoxide has been already described among the acids. It may be directly procured, by adding nitrate of lead to the above nitrochromate of potash, and digesting the beautiful orange precipitate of chromate of lead with moderately strong muriatic acid, till its power of action be exhausted. The fluid produced is to be passed through a filter, and a little oxide of silver very gradually added, till the whole solution becomes of a deep red tint. This liquor, by slow evaporation, deposits small ruby-red crystals, which are the hydrated chromic acid. The prime equivalent of chromic acid deduced from the chromates of barytes and lead by Berzelius, is 6.544, if we suppose them to be neutral salts. According to this chemist, the acid contains double the oxygen that the green oxide does. But if these chromates be regarded as subsalts, then the acid prime would be 13.088, consisting of 6 oxygen + 7.088 metal; while the protoxide would consist of 3 oxygen + 7.088 metal; and the deutoxide of an intermediate proportion.

M. Unverdorben states that if chromate of lead be distilled with common salt, and anhydrous sulphuric acid, a reddish gas is obtained, consisting of chromium combined with chlorine. Water converts it into chromic and muriatic acids. By passing the above gas through a cold tube, the chloride of chromium is entirely condensed, while the chlorine and muriatic acid evolved along with it pass off. The liquid chloride is of a fine blood red colour, heavier than water, very volatile, fuming in the air, and then of a colour analogous to that of nitrous acid when in vapour. It rapidly attacks mercury, acts on sulphur with much energy, and a hissing noise; it detonates with phosphorus, even when the particles of each do not exceed the size of a pin's head. *Journ. of Science*, xxii. 211.

CHRYSOBERYL. *Cymophane* of Haüy. This mineral is usually got in round pieces about the size of a pea, but it is found crystallized in eight-sided prisms, terminated by six-sided summits. Colour, asparagus green; lustre, vitreous; fracture, conchoidal; it is semitransparent and brittle, but scratches quartz and beryl. Sp. gr. 3.76. It is infusible before the blowpipe. It has double refraction, and becomes electric by friction. Its primitive form is a rectangular parallelopiped. Its constituents, according to Klaproth, are 71 alumina, 18 silica, 6 lime, 1½ oxide of iron.

The summits of the prisms of chrysoberyl are sometimes so cut into facettes that the solid acquires 28 faces. It is found at Brazil, Ceylon, Connecticut, and perhaps Nertschink in Siberia. This mineral has nothing to do with the chrysoberyl of Pliny, which was probably a variety of beryl of a greenish-yellow colour.

CHRYSOCOLLA. The Greek name for borax.

CHRYSOLITE. *Peridot* of Haüy. Topaz of the ancients, while our topaz is their chrysolite. Chrysolite is the least hard of all the gems. It is scratched by quartz and the file. Its crystals are well formed compressed prisms, of eight sides at least, terminated by a wedged form or pyramidal summit, truncated at the apex. Its primitive form is a right prism, with a rectangular base. It has a strong double refraction, which is observed in looking across one of the large sides of the summit and the opposite face of the prism. The lateral planes are longitudinally streaked. The colour is pistachio green, and other shades. External lustre splendent. Transparent; fracture, conchoidal. Scratches felspar. Brittle. Sp. gr. 3.4. With borax, it fuses into a pale green glass. Its constituents are 39 silica, 43.5 magnesia, 19 of oxide of iron, according to Klaproth; but Vauquelin found 38, 50.5, and 9.5. Chrysolite comes from Egypt, where it is found in alluvial strata. It has also been found in Bohemia, and in the Circle of Bunzlau.

CHRYSOPRASE. A variety of calcedony. It is either of an apple or leek-green colour. Its fracture is even, waxy, sometimes a little splintery. Translucent, with scarcely any lustre. Softer than calcedony, and rather tough. Sp. gr. 2.5. A strong heat whitens it. It consists of 96.16 silica, 0.08 alumina, 0.83 lime, 0.08 oxide of iron, and 1 oxide of nickel, to which it probably owes its colour. It has been found hitherto only at Kosemütz in Upper Silesia. The mountains which enclose it are composed chiefly of serpentine, potstone, talc, and other unctuous rocks that almost all contain magnesia. It is found in veins or interrupted beds in the midst of a green earth which contains nickel. It is used in jewellery.

CHUSITE. A mineral found by Saussure in the cavities of porphyries in the environs of Limbourg. It is yellowish or greenish and translucent; its fracture is sometimes perfectly smooth, and its lustre greasy; at other times it is granular. It is very brittle. It melts easily into a translucid enamel, enclosing air bubbles. It dissolves entirely, and without effervescence, in acids.

CHYAZIC. See ACID (FERROPRUSSIC).

CHYLE. By the digestive process in the stomach of animals, the food is converted into a milky fluid, called *chyme*, which passing into the intestine, is mixed with pancreatic juice and bile, and thereafter resolved into chyle and feculent matter. The former is taken up by the lacteal absorbent vessels of the intestines, which coursing along the mesenteric web, terminate in the thoracic duct. This finally empties its contents into the *vena cava*.

Chyle taken soon after the death of an animal, from the thoracic duct, resembles milk in appearance. It has no smell, but a slightly acido-saccharine taste; yet it blues reddened litmus paper by its unsaturated alkali. Soon after it is drawn from the duct, it separates by coagulation into a thicker and thinner matter. 1. The former, or curd, seems intermediate between albumen and fibrin. Potash and soda dissolve it with a slight exhalation of ammonia. Water of ammonia forms with it a reddish solution. Dilute sulphuric acid dissolves the *coagulum*; and very weak nitric acid changes it into adipocere. By heat, it is converted into a charcoal of difficult incineration, which contains common salt and phosphate of lime, with minute traces of iron. 2. From the serous portion, heat, alcohol, and acids, precipitate a copious coagulum of albumen. If the alcohol be hot, a little matter analogous to the substance of brain is subsequently deposited. By evaporation and cooling, Mr. Brande obtained crystals analogous to the sugar of milk. Dr. Marcet found the chyle of graminivorous animals thinner and darker, and less charged with albumen, than that of carnivorous. In the former, the weight of the fluid part to that of the coagulum was nearly 2 to 1; but a serous matter afterwards oozed out, which reduced the clot to a very small volume.

CHYME. Dr. Marcet examined chyme from the stomach of a turkey. It was a homogeneous, brownish opaque pulp, having the smell peculiar to poultry. It was neither acid nor alkaline, and left one-fifth of solid matter by evaporation. It contained albumen. From the incineration of 1000 parts, 12 parts of charcoal resulted, in which iron, lime, and an alkaline muriate were distinguished. See DIGESTION.

CIMOLITE, or CIMOLIAN EARTH. The *cimolia* of Pliny, which was used both medicinally and for cleaning cloths by the ancients, and which has been confounded with fullers' earth and tobacco-pipe clay, has lately been brought from Argentiera, the ancient Cimolus, by Mr. Hawkins, and examined by Klaproth.

It is of a light greyish-white colour, acquiring superficially a reddish tint by exposure to the air; massive; of an earthy, uneven, more or less slaty fracture; opaque; when shaved with a knife, smooth and of a greasy lustre; tenacious, so as not without difficulty to be powdered or broken; and adhering pretty firmly to the tongue. Its specific gravity is 2. It is immediately penetrated by water, and developes itself into thin laminæ of a curved slaty form. Triturated with water it forms a pappy mass; and 100 grains will give three ounces of water the appearance and consistence of a thickish cream. If left to dry after being thus ground, it detaches itself in hard bands, somewhat flexible, and still more difficult to pulverize than before.

It appeared on analysis to consist of silex 63, alumina 23, oxide of iron 1.25, water 12.

Ground with water, and applied to silk and woollen, greased with oil of almods, the oil was completely discharged by a slight washing in water, after the stuffs had been hung up a day to dry, without the least injury to the beauty of the colour. Mr. Klaproth considers it as superior to our best fullers' earth; and attributes its properties to the minutely divided state of the silex, and its intimate combination with the alumina. It is still used by the natives of Argentiera for the same purposes as of old.

According to Olivier the island of Argentiera is entirely volcanic, and the Cimolian earth is produced by a slow and gradual decomposition of the porphyries, occasioned by subterranean fires. He adds, that he collected specimens of it in all the states through which it passes.

CINCHONA. The quinquina and kina of the French, is the bark of several species of cinchona, which grow in South America. Of this bark there are three varieties, the red, the yellow, and the pale.

1. The red is in large, easily pulverized pieces, which furnish a reddish-brown powder, having a bitter astringent taste. The watery infusion reddens vegetable blues, from some free citric acid. It contains also muriates of ammonia and lime. The bark contains extractive, resin, bitter principle, and tannin. 2. The *yellow Peruvian* bark was first brought to this country about the year 1790; and it resembles pretty closely in composition the red species, only it yields a good deal of kinate of lime in plates. 3. The pale cinchona is that generally employed in medical practice, as a tonic and febrifuge. M. Vauquelin made infusions of all the varieties of cinchona he could procure, using the same quantities of the barks and water, and leaving the powders infused for the same time. He observed, 1. That certain infusions were precipitated abundantly by infusion of galls, by solution of glue, and tartar emetic. 2. That some were precipitated by glue, but not by the two other re-agents; and 3. That others were, on the contrary, by nutgalls and tartar emetic, without being affected by glue. 4. And that there were some which yielded no precipitate by nutgalls, tannin, or emetic tartar. The cinchonas that furnished the first infusion were of excellent quality; those that afforded the fourth were not febrifuge; while those that gave the second and third were febrifuge, but in a smaller degree than the first. Besides mucilage, kinate of lime, and woody fibre, he obtained in his analyses a resinous substance, which appears not to be identic in all the species of bark. It is very bitter; very soluble

in alcohol, in acids, and alkalis; scarcely soluble in cold water, but more soluble in hot. It is this body which gives to infusions of cinchona the property of yielding precipitates by emetic tartar, galls, gelatin; and in it, the febrifuge virtue seems to reside. It is this substance in part which falls down on cooling decoctions of cinchona, and from concentrated infusions. A table of precipitations by glue, tannin, and tartar emetic, from infusions of different barks, has been given by M. Vauquelin; but as the particular species are difficult to define, we shall not copy it.

Analysis of the cinchona condaminœa (grey bark) by MM. Pelletier and Caventou. They found it composed of, 1. cinchonina, united to kinic acid; 2. green fatty matter; 3. red colouring matter, slightly soluble; 4. tannin; 5. yellow colouring matter; 6. kinate of lime; 7. gum; 8. starch; 9. lignine.

CINCHONINA. A salifiable base, or vegetable alkali, discovered in cinchona condaminea, by MM. Pelletier and Caventou. The person, however, who first recognized its existence, though he did not ascertain its alkaline nature, or study its combinations with acids, was M. Gomis of Lisbon.

Mr. Brande prescribes the following process for separating cinchonina from Peruvian bark, (*cinchona lancifolia*). A pound of bruised bark is boiled in about a gallon of water, to which three fluid drachms of sulphuric acid have been previously added. A similar decoction is repeated with about half the quantity of liquid, and so on till all the soluble matter is extracted. The decoctions are then mixed together, and strained; and powdered slaked lime is added in a proportion, somewhat greater than necessary to saturate the acid; the precipitate that ensues (a mixture of cinchonina and sulphate of lime) is collected, dried, and boiled for some minutes in strong alcohol, which is then decanted off *while still hot*, and fresh portions successively added for the repetition of the same operation, until it ceases to act on the residuum, which is then merely sulphate of lime. The different alcoholic solutions are then put into a retort or still, and considerably evaporated, during which, and especially on cooling, acicular crystals of cinchonina are deposited. When the whole is thus collected, the crystals, if yellow or discoloured, must be again dissolved in boiling alcohol, and thus, by re-crystallization, they will be obtained colourless. *Manual of Pharmacy*, p. 61.

The following process for extracting cinchonina is that of M. Henry fils, which the above French chemists approve of. A kilogramme of bark reduced into a pretty fine powder is to be acted on twice with heat, by a dilute sulphuric acid, consisting of 50 or 60 grammes, diluted with 8 kilogrammes of water for each time. The filtered decoctions are very bitter, have a reddish colour, which assumes on cooling a yellowish tint. To discolour (blanch) these liquors, and saturate the acid, either pulverized quicklime or magnesia may be employed. The liquors, entirely deprived of colour, are to be passed through a cloth, and the precipitate which forms is to be washed with a small quantity of water, to separate the excess of lime (if this earth has been used). The deposit on the cloth, well drained and almost completely deprived of moisture for 12 hours, after having been put three successive times to digest in alcohol of 36° (0·837), will furnish, by distilling of the liquid alcohol, a brown viscid matter, becoming brittle on cooling. It is to be acted on with water sharpened with sulphuric acid, and the refrigerated liquor will afford about 30 grammes of white crystals, entirely soluble in alcohol, scarcely soluble in cold water, but more in boiling water, particularly if this be slightly acidulated. They consist of pure sulphate of cinchonina. They ought to be brilliant, crystallized in parallelopipeds, very hard, and of a glassy white. It should burn, without leaving any residuum. Other processes have been given, of which a full account will be found in the 12th volume of the Journal of Science, p. 325. From a solution of the above salt, the cinchonina may be easily obtained by the addition of any alkali. The cinchonina falls down, and may be afterwards dissolved in alcohol, and crystallized by evaporation. Its form is a rhomboidal prism, of 108° and 72°, terminated by a bevelment. It has but little taste, requiring 7000 parts of water for its solution; but when dissolved in alcohol, or an acid, it has the bitter taste of bark. When heated, it does not fuse before decomposition.

According to Mr. Brande, cinchonina consists of

Carbon	80·20
Azote	12·85
Hydrogen	6·85
	99·90

By another experiment, he found its constituents to be

Carbon	78·4
Azote	14·6
Hydrogen	7·5
	100·5

He could detect no trace of oxygen in it. *Journal of Science*, xvi. 282.

MM. Dumas and Pelletier, in an elaborate memoir on the ultimate analysis of vegetables, represent cinchonina as consisting of

Carbon	76.97
Azote	9·02
Hydrogen	6·22
Oxygen	7·97
	100·18

It dissolves in only very small quantities in the oils, and in sulphuric ether.

The sulphate is composed of cinchonina, 100
Sulphuric acid, 13

whence the prime equivalent would appear to be 38·5. The muriate is more soluble. It consists of

Cinchonina	100
Muriatic acid	7·9

The nitrate is uncrystallizable. Gallic, oxalic, and tartaric acids, form neutral salts with cinchonina, which are soluble only with excess of acid. Hence infusion of nut-galls gives, with a decoction of good cinchona, an abundant precipitate of gallate of cinchonina.

M. Baup states the composition of crystallized neutral sulphate of cinchonina to be

1 atom cinchonina	39	84·324
1 —— sulphuric acid	5	10·811
2 —— water	2·25	4·865
	46·25	100·000

Supersulphate of cinchonina, he says, contains 2 atoms of acid, and 9 of water. The latter appears in imperfect rhomboidal octohedra; the former in rhomboidal prisms. *Ann. de Chim. et de Phys.* xxvii. 323.

M. Robiquet gives as the composition of a subsulphate of cinchonina of the first crystallization,

Sulphuric acid	11·3
Cinchonina	79·0

The alkaline base found in yellow barks is called QUININA. It is extracted in exactly the same way. Red bark contains a mixture of these two alkalis. The febrifuge virtue of the sulphates is considered to be very great. See QUININA.

CINNABAR. An ore of mercury, consisting of that metal united with sulphur.

CINNAMON STONE. The colours of this rare mineral are blood-red, and hyacinth-red, passing into orange-yellow. It is found always in roundish pieces; lustre splendent; fracture imperfect conchoidal; fragments angular; transparent and semi-transparent; scratches quartz with difficulty; somewhat brittle; sp. gr. 3·53; fuses into a brownish-black enamel. Its constituents are 38·8 silica, 21·2 alumina, 31·25 lime, and 6·5 oxide of iron. It is found in the sand of rivers in Ceylon.

CIPOLIN. The Cipolin from Rome is a green marble with white zones; it gives fire with steel, though difficultly. One hundred parts of it contain 67·8 of carbonate of lime; 25 of quartz; 8 of schistus; 0·2 of iron, beside the iron contained in the schistus. The cipolin from Autun, 83 parts carbonate of lime, 12 of green mica, and one of iron.

CISTIC OXIDE. A peculiar animal product, discovered by Dr. Wollaston. It constitutes a variety of urinary CALCULUS, which see.

CITRIC ACID. Acid of limes. It has been found nearly unmixed, with other acids, not only in lemons, oranges, and limes, but also in the berries of *vaccinium oxycoccos*, or cranberry, *vaccinium vitis idæa*, or red-whortleberry, of birdcherry, nightshade, hip, in unripe grapes and tamarinds. Gooseberries, currants, bilberries, beamberries, cherries, strawberries, cloudberries, and raspberries, contain citric acid mixed with an equal quantity of mallic acid. The onion yields citrate of lime. See ACID (CITRIC).

CITRATES. Salts formed by CITRIC ACID, which see.

CIVET is collected betwixt the anus and the organs of generation of a fierce carnivorous quadruped met with in China and the East and West Indies, called a civet-cat, but bearing a greater resemblance to a fox or marten than a cat.

Several of these animals have been brought into Holland, and afford a considerable branch of commerce, particularly at Amsterdam. The civet is squeezed out, in summer every other day, in winter twice a-week: the quantity procured at once is from two scruples to a drachm or more. The juice thus collected is much purer and finer than that which the animal sheds against shrubs or stones in its native climates.

Good civet is of a clear yellowish or brownish colour, not fluid, nor hard, but about the consistence of butter or honey, and uniform throughout; of a very strong smell; quite offensive when undiluted; but agreeable when only a small portion of civet is mixed with a large one of other substances.

Civet unites with oils, but not with alcohol. Its nature is therefore not resinous.

M. Boutron-Charlard states, that in an unexceptionably good civet, semi-fluid, unctuous, and yellow, he found free ammonia, stearine, elaïne, mucus, resin, volatile oil, yellow colouring substance, and salts. No benzoic acid could be detected in it. *Journ. de Pharmacie* for 1824, p. 537.

CLARIFICATION is the process of freeing a fluid from heterogeneous matter or feculencies, though the term is seldom applied to the mere mechanical process of straining, for which see FILTRATION.

Albumen, gelatine, acids, certain salts, lime, blood, and alcohol, in many cases serve to clarify fluids that cannot be freed from their impurities by simple percolation.

Albumen or gelatine, dissolved in a small portion of water, is commonly used for fining vinous liquors, as it inviscates the feculent matter, and gradually subsides with it to the bottom. Albumen is particularly used for fluids, with which it will combine when cold.

as syrups; it being coagulated by the heat, and then rising in a scum with the dregs.

Heat alone clarifies some fluids, as the juices of plants, in which however the albumen they contain is probably the agent.

A couple of handfuls of marle, thrown into the press, will clarify cyder, or water-cyder.

CLAY (PURE). See ALUMINA.

CLAY. The clays being opaque and non-crystallized bodies, of dull fracture, afford no good principle for determining their species; yet as they are extensively distributed in nature, and are used in many arts, they deserve particular attention. The argillaceous minerals are all sufficiently soft to be scratched by iron; they have a dull or even earthy fracture; they exhale, when breathed on, a peculiar smell called argillaceous. The clays form with water a plastic paste, possessing considerable tenacity, which hardens with heat, so as to strike fire with steel. Marles and chalks also soften in water, but their paste is not tenacious, nor does it acquire a siliceous hardness in the fire. The affinity of the clays for moisture is manifested by their sticking to the tongue, and by the intense heat necessary to make them perfectly dry. The odour ascribed to clays breathed upon, is due to the oxide of iron mixed with them. Absolutely pure clays emit no smell.

1. *Porcelain earth*, the kaolin of the Chinese.—This mineral is friable, meagre to the touch, and, when pure, forms with difficulty a paste with water. It is infusible in a porcelain furnace. It is of a pure white, verging sometimes upon the yellow or flesh-red. Some present particles of mica, which betray their origin to be from felspar or graphic granite. It scarcely adheres to the tongue. Sp. gr. 2.2. It is found in primitive mountains, amid blocks of granite, forming interposed strata. Kaolins are sometimes preceded by beds of a micaceous rock of the texture of gneiss, but red and very friable. This remarkable disposition has been observed in the Kaolin quarries of China, in those of Alençon, and of Saint Yriex near Limoges. The constituents of kaolin are 52 silica, 47 alumina, 0.33 oxide of iron; but some contain a notable proportion of water in their recent state. The Chinese and Japanese kaolins are whiter and more unctuous to the touch than those of Europe. The Saxon has a slight tint of yellow or carnation, which disappears in the fire, and therefore is not owing to metallic impregnation. At Saint Yriex the kaolin is in a stratum and also in a vein, amid blocks of granite, or rather the felspar rock, which the Chinese call petuntze. The Cornish kaolin is very white and unctuous to the touch, and obviously is formed by the disintegration of the felspar of granite.

2. *Potters' clay*, or *plastic clay*.—The clays of this variety are compact, smooth, and almost unctuous to the touch, and may be polished by the finger when they are dry. They have a great affinity for water, form a tenacious paste, and adhere strongly to the tongue. The paste of some is even slightly transparent. They acquire great solidity, but are infusible in the porcelain furnace. This property distinguishes them from common clays, employed for coarse earthen-ware. Some of them remain white, or become so in a high heat; others turn red. Sp. gr. 2. The slaty potters' clay of Werner has a dark ash-grey colour; principal fracture imperfectly conchoidal, cross fracture earthy; fragments tabular, rather light, and feels more greasy than common potters' clay. Vauquelin's analysis of the plastic clay of Forges-les-Eaux, employed for making glass-house pots, as well as pottery, gave 16 alumina, 63 silica, 1 lime, 8 iron, and 10 water. Another potters' clay gave 33.2 and 43.5 of alumina and silica, with 3.5 lime.

3. *Loam.*—This is an impure potters' clay mixed with mica and iron ochre. Colour yellowish-grey, often spotted yellow and brown. Massive, with a dull glimmering lustre from scales of mica. Adheres pretty strongly to the tongue, and feels slightly greasy. Its density is inferior to the preceding.

4. *Variegated clay.*—Is striped or spotted with white, red, or yellow colours. Massive, with an earthy fracture, verging on slaty. Shining streak. Very soft, sometimes even friable. Feels slightly greasy, and adheres a little to the tongue. Sectile. It is found in Upper Lusatia.

5. *Slate clay.*—Colour grey, or greyish-yellow. Massive. Dull or glimmering lustre, from interspersed mica. Slaty fracture, approaching sometimes to earthy. Fragments tabular. Opaque, soft, sectile, and easily broken. Sp. gr. 2.6. Adheres to the tongue, and breaks down in water. It is found along with coal, and in the floetz trap formation.

6. *Claystone.*—Colour grey, of various shades, sometimes red, and spotted or striped. Massive. Dull lustre, with a fine earthy fracture, passing into fine grained uneven, slaty, or splintery. Opaque, soft, and easily broken. Does not adhere to the tongue, and is meagre to the touch. It has been found on the top of the Pentland hills in Scotland, and in Germany.

7. *Adhesive slate.*—Colour light greenish-grey. Internal lustre dull; fracture in the large, slaty; in the small, fine earthy. Fragments slaty. Opaque. Shining streak. Sectile. Easily broken or exfoliated. Adheres strongly to the tongue, and absorbs water rapidly with the emission of air bubbles, and a crackling sound. It is found at Montmartre near Paris, between blocks of impure gypsum, in large straight plates like sheets of pasteboard. It is found also at Menilmontant, enclosing menilite. Klaproth's analysis is 62.5 silica, 8 magnesia, 0.5 alumina, 0.25 lime, 4 oxide

of iron, 22 water, and 0.75 charcoal. Its sp. gr. is 2.08.

8. *Polishing slate* of Werner.—Colour, cream-yellow, in alternate stripes. Massive. Lustre dull. Slaty fracture. Fragments tabular. Very soft, and adheres to the tongue. Smooth, but meagre to the touch. Sp. gr. in its dry state 0.6; when imbued with moisture 1.9. It has been found only in Bohemia. Its constituents are 79 silica, 1 alumina, 1 lime, 4 oxide of iron, and 14 water.

9. *Common clay* may be considered to be the same as *loam*.—Besides the above, we have the analysis of some pure clays, the results of which show a very minute quantity of silica, and a large quantity of sulphuric acid. Thus, in one analyzed by Bucholz, there was 1 silica, 31 alumina, 0.5 lime, 0.5 oxide of iron, 21.5 sulphuric acid, 45 water, and 0.5 loss. Simon found 19.35 sulphuric acid in 100 parts. We must regard these clays as subsulphates of alumina.

CLAY-SLATE. Argillaceous schistus, the Argillite of Kirwan. Colour, bluish-grey, and greyish-black of various shades. Massive. Internal lustre shining or pearly. Fracture foliated. Fragments tabular. Streak, greenish-white. Opaque. Soft. Sectile. Easily broken. Sonorous, when struck with a hard body. Sp. gr. 2.7. Its constituents are 48.6 silica, 23.5 alumina, 1.6 magnesia, 11.3 peroxide of iron, 0.5 oxide of manganese, 4.7 potash, 0.3 carbon, 0.1 sulphur, 7.6 water and volatile matter. Clay-slate melts easily by the blowpipe into a shining scoria. This mineral is extensively distributed, forming a part of both primitive and transition mountains. The great beds of it are often cut acróss by thin seams of quartz or carbonate of lime, which divide them into rhomboidal masses. Good slates should not imbibe water. If they do, they soon decompose by the weather.

CLAY IRON-STONE. See ORES OF IRON.

CLEAVAGE OF CRYSTALS. The mechanical division of crystals, by showing the direction in which their *laminæ* can separate, enables us to determine the mutual inclination of these *laminæ*: Werner called it *durchgang*, but he attended only to the number of directions in which this mechanical division of the plates, or cleavage, could be effected. In the interior of many minerals, the direction of the cleavage may be frequently seen, without using any mechanical violence.

CLEAVLANDITE. A mineral formerly ranked among felspars; but they differ in this, that the 13 or 14 per cent. of potash in felspar, is replaced by about 10 per cent. of soda in the cleavlandite, which moreover is not so hard as felspar. Mr. Levy considers the primitive form of felspar to be an oblique rhombic prism; and that of cleavlandite a doubly oblique prism. The crystals of the latter have a certain brilliancy which does not belong to the former. The localities of cleavlandite are very numerous; but the finest crystals come from the Tyrol and St. Gothard. The largest from Siberia, where they are met upon the same specimen with large crystals of reddish felspar and smoky quartz. The most transparent come from Dauphiny. This mineral is generally white, but is also found bluish and blue, and of a dingy red. It is sometimes regularly laminated, affording distinct cleavages parallel to all the planes of a doubly oblique prism, yielding by the reflective goniometer, in one direction, alternate measurements of 93° 30′, and 86° 30′; in another of 119° 30′, and 60° 30′; and in the third of 115° and 65°. It was at first called albite and siliceous felspar. It consists of silica 70.7, alumina 19.8, soda 9, lime 0.2, oxide of manganese 0.1.—*Stromeyer*.

CLIMATE. The prevailing constitution of the atmosphere, relative to heat, wind, and moisture, peculiar to any region. This depends chiefly on the latitude of the place, its elevation above the level of the sea, and its insular or continental position. Springs which issue from a considerable depth, and caves about 50 feet under the surface, preserve an uniform temperature through all the vicissitudes of the season. This is the mean temperature of that country. From a comparison of observations, Professer Mayer constructed the following empirical rule for finding the relation between the latitude and the mean temperature, in centesimal degrees, at the level of the sea.

Multiply the square of the cosine of the latitude by the constant number 29, *the product is the temperature.* The variation of temperature for each degree of latitude is hence denoted centesimally with very great precision, by half the sine of double the latitude.

	Mean temperatures.		Height of curve of
Latitude.	Cent.	Fahr.	congelation in feet.
0°	29°	84·2	15207
5	28·78	83·8	15095
10	28·13	82·6	14764
15	27·06	80·7	14220
20	25·61	78·1	13478
25	23.82	74·9	12557
30	21·75	71·1	11484
35	19·46	67.	10287
40	17·01	62·6	9001
45	14·50	58·1	7671
50	11·98	53·6	6334
55	9·54	49.2	5034
60	7·25	45·0	3818
65	5·18	41·3	2722
70	3·39	38·1	1778
75	1·94	35·5	1016
80	0·86	33·6	457
85	0·22	32·4	117
90	0·0	32·0	00

The following table represents the results of some interesting observations made under the direction of Mr. Ferguson of Raith, at Abbotshall in Fife, about 50 feet above the level of the sea, in latitude 56° 10′. The large and strong bulbs of the thermometers were buried in the ground at various depths, while the stems rose above the surface for inspection.

	1816.				1817.			
	1 foot.	2 feet.	3 feet.	4 feet.	1 foot.	2 feet.	3 feet.	4 feet.
January,	33°	36.3°	40.7°	43°	35.6	38.7	40.5	45.1
February,	33.7	36	39.0	42	37.0	40.0	41.6	42.7
March,	35	36.7	39.6	42.3	39.4	40.2	41.7	42 5
April,	39.7	38.4	41.4	43.8	45.0	42.4	42.6	42.6
May,	44.0	43.3	43.4	44.0	46.8	44.7	44.6	44.2
June,	51.6	50.0	47.1	45.8	51.1	49.4	47.6	47.8
July,	54.0	52.5	55.4	47.7	55.2	55.0	51.4	49.6
August,	50.0	52.5	50.6	49.4	53.4	53.9	52.0	50.0
September,	51.6	51.3	51.8	50.0	53.0	52.7	52.0	50.7
October,	47.0	49.3	49.7	49.6	45.7	49.4	49.4	49.8
November,	40.8	43.8	46.3	45.6	41.0	44.7	47.0	47.6
December.	35.7	40.0	43.0	46.0	37.9	40.8	44.9	46.4
Mean of whole year.	43.8	44·1	45.1	46	44.9	45.9	46.2	46.6

Had the thermometers been sunk deeper, they would undoubtedly have indicated 47.7, which is the mean temperature of the place, as is shown by a copious spring.

The lake of Geneva, at the depth of 1000 feet, was found by Saussure to be 42°; and below 160 feet from the surface there is no monthly variation of temperature. The lake of Thun, at 370 of depth, and Lucerne at 640, had both a temperature of 41°, while the waters at the surface indicated respectively 64° and 68½° Fahr. Barlocci observed, that the Lago Sabatino, near Rome, at the depth of 490 feet, was only 44½°, while the thermometer stood on its surface at 77°. Mr. Jardine has made accurate observations on the temperatures of some of the Scottish lakes, by which it appears, that the temperature continues uniform all the year round, about 20 fathoms under the surface. In like manner, the mine of Dannemora in Sweden, which presents an immense excavation, 200 or 300 feet deep, was observed at a period when the working was stopped, to have great blocks of ice lying at the bottom of it. The bottom of the main shaft of the silver mine of Kongsberg in Norway, about 300 feet deep, is covered with perpetual snow. Hence, likewise, in the deep crevices of Ætna and the Pyrenees, the snows are preserved all the year round. It is only, however, in such confined situations that the lower strata of air are thus permanently cold. In a free atmosphere, the gradation of temperature is reversed, or the upper regions are colder, in consequence of the increased capacity for heat of the air, by the diminution of the density. In the milder climates, it will be sufficiently accurate, in moderate elevations, to reckon an ascent of 540 feet for each centesimal degree, or 100 yards for each degree on Fahrenheit's scale of diminished temperature. Dr. Francis Buchanan found a spring at Chitlong, in the lesser valley of Nepal, in Upper India, which indicated the temperature of 14.7 centesimal degrees, which is 8.1° below the standard for its parallel of latitude, 27° 38′. Whence 8.1 × 540 = 4374 feet, is the elevation of that valley. At the height of a mile this rule would give about 33 feet too much. The decrements of temperature augment in an accelerated progression as we ascend.

Ben Nevis, the highest mountain in Great Britain, stands in latitude 57°, where the curve of congelation reaches to 4534 feet. But the altitude of the summit of the mountain is no more than 4380 feet; and therefore, during two or three weeks in July, the snow disappears. The curve of congelation must evidently rise higher in summer, and sink lower in winter, producing a zone of fluctuating ice, in which the *glaciers* are formed.

In calculating the mean temperature of countries at different distances from the equator, the warmth has been referred solely to the sun. But Mr. Bald has published, in the first number of the Edinburgh Philosophical Journal, some facts apparently incompatible with the idea of the interior temperature of the earth being deducible from the latitude of the place, or the mean temperature at the surface. The following table presents, at one view, the temperature of air and water, in the deepest coal-mines in Great Britain.

Whitehaven Colliery, county of Cumberland.

Air at the surface, . . .	55° F.
A spring at the surface, . .	49
Water at the depth of 480 feet, .	60
Air at same depth, . . .	63
Air at depth of 600 feet, . .	66
Difference between water at surface and at 480 feet, . . .	11

Workington Colliery, county of Cumberland.

Air at the surface, . . .	56°
A spring at the surface, . .	48
Water 180 feet down, . .	50
Water 504 feet under the level of the ocean, and immediately beneath the Irish Sea, . . .	60
Difference between water at surface and bottom, . . .	12

Teem Colliery, county of Durham.

Air at pit bottom, 444 feet deep,	68
Water at same depth, . .	61
Difference between the mean temperature of water at surface = 49°, and 444 feet down, . .	12

Percy Main Colliery, county of Northumberland.

Air at the surface, . . .	42
Water about 900 feet deeper than the level of the sea, and under the bed of the river Tyne, . .	68
Air at the same depth, . .	70
At this depth Leslie's hygrometer indicated dryness = 83°.	
Difference between mean temperature of water at surface = 49°, and at 900 feet down, . . .	19

Jarrow Colliery, county of Durham.

Air at surface, ...	49½
Water 882 feet down, . .	68
Air at same depth, . .	70
Air at pit bottom, . .	64
Difference between the mean temperature of water at surface = 49°, and 882 feet down, . . .	19

The engine pit of Jarrow is the deepest perpendicular shaft in Great Britain, being 900 feet to the foot of the pumps.

Killingworth Colliery, county of Northumberland.

Air at the surface, . .	48
Air at bottom of pit, 790 feet down,	51
Air at depth of 900 feet from the surface, after having traversed a mile and a half from the bottom of the downcast pit, . .	70
Water at the most distant forehead or mine, at the great depth of 1200 feet from the surface, . .	74
Air at the same depth, . .	77
Difference betwixt the mean temperature of the water at the surface = 49°, and water at the depth of 1200 feet, ...	25°
Distilled water boils at this depth at	213
Do. do. at surface, .	210½

M. Humboldt has stated, that the temperature of the silver mine at Valenciana in New Spain is 11° above the mean temperature of Jamaica and Pondicherry, and that this temperature is not owing to the miners and their lights, but to *local* and *geological* causes. To the same local and geological causes we must ascribe the extraordinary elevation of temperature observed by Mr. Bald. He further remarks, that the deeper we descend, the drier we find the strata, so that the roads through the mines require to be watered, in order to prevent the horse-drivers from being annoyed by the dust. This fact is adverse to the hypothesis of the heat proceeding from the chemical action of water on the strata of coal. As for the pyrites intermixed with these strata, it does not seem to be ever decomposed, while it is *in situ*. The perpetual circulation of air for the respiration of the miners must prevent the lights from having any considerable influence on the temperature of the mines.

The meteorological observations now made and published with so much accuracy and regularity in various parts of the world will soon, it is hoped, make us better acquainted with the various local causes which modify climates, than we can pretend to be at present. The accomplished philosophical traveller, M. de Humboldt, published an admirable systematic view of the mean temperatures of different places, in the third volume of the Memoirs of the Society of Arcueil. His paper is entitled, Of Isothermal Lines (lines of the same temperature), and the Distribution of Heat over the Globe. By comparing a great number of observations made between 46° and 48° N. lat., he found, that at the hour of sunset the temperature is very nearly the mean of that at sunrise and two hours after noon. Upon the whole, however, he thinks, that the two observations of the extreme temperatures will give us more correct results.

The difference which we observe in cultivated plants depends less upon mean temperature than upon direct light and the serenity of the atmosphere; but wheat will not ripen if the mean temperature descend to 47.6°.

Europe may be regarded as the western part of a great continent, and subject to all those influences which make the western sides of all continents warmer than the eastern. The same difference that we observe on the two sides of the Atlantic exists on the two sides of the Pacific. In the north of China, the extremes of the seasons are much more felt than in the same latitudes in New California, and at the mouth of the Columbia. On the eastern side of North America, we have the same extremes as in China; New York has the summer of Rome, and the winter of Copenhagen; Quebec has the summer of Paris, and the winter of Petersburgh. And in the same way in Pekin, which has the mean temperature of Britain, the heats of summer are greater than those at Cairo, and the cold of winter as severe as that at Upsal. This analogy between the eastern coasts of Asia and of America sufficiently proves, that the inequalities of the seasons depend upon the prolongation and enlargement of the continents towards the pole, and upon the frequency of N. W. winds, and not upon the proximity of any elevated tracts of country.

Ireland, says Humboldt, presents one of the most remarkable examples of the combination of very mild winters with cold summers; the mean temperature in Hungary for the month of August is 71.6°; while in Dublin it is only 60.8°. In Belgium and Scotland, the winters are milder than at Milan.

In the article Climate, Supplement to the Encyclopædia Britannica, the following simple rule is given for determining the change of temperature produced by sudden rarefaction or condensation of air. *Multiply 25 by the difference between the density of air and its reciprocal, the product will be the difference of temperature on the centigrade scale.* Thus, if the density be twice, or one half $25^\circ \times (2-\frac{1}{2}) = 37\frac{1}{2}^\circ$ cent. $= 67.5^\circ$ Fahr. indicates the change of temperature by doubling the density or rarity of air. Were it condensed 30 times, then, by this formula, we have 749° for the elevation of temperature, or $25^\circ (30^\circ - \frac{1}{30})$. But M. Gay Lussac says, that a condensation of air into one-fifth of its volume, is sufficient to ignite tinder; a degree of heat which he states at 300° centigrade = 572° Fahr. (Journal of Science, vol. vii. p. 177.) This experimental result is incompatible with Professor Leslie's formula, which gives only 112.5° for the heat produced by a condensation into one-fifth.

It appears very probable, that the climates of European countries were more severe in ancient times than they are at present. Cæsar says, that the vine could not be cultivated in Gaul, on account of its winter-cold. The rein-deer, now found only in the zone of Lapland, was then an inhabitant of the Pyrenees. The Tiber was frequently frozen over, and the ground about Rome covered with snow for several weeks together, which almost never happens in our times. The Rhine and the Danube, in the reign of Augustus, were generally frozen over, for several months of winter. The barbarians who overran the Roman empire a few centuries afterwards, transported their armies and waggons across the ice of these rivers. The improvement that is continually taking place in the climate of America, proves, that the power of man extends to phenomena, which, from the magnitude and variety of their causes, seemed entirely beyond his control. At Guiana, in South America, within five degrees of the line, the inhabitants living amid immense forests, a century ago, were obliged to alleviate the severity of the cold by evening fires. Even the duration of the rainy season has been shortened by the clearing of the country, and the warmth is so increased, that a fire now would be deemed an annoyance. It thunders continually in the woods, rarely in the cultivated parts.

Drainage of the ground, and removal of forests, however, cannot be reckoned among the sources of the increased warmth of the Italian winters. Chemical writers have omitted to notice an astronomical cause of the progressive amelioration of the climates of the northern hemisphere. In consequence of the apogee portion of the terrestrial orbit being contained between our vernal and autumnal equinox, our summer half of the year, or the interval which elapses between the sun's crossing the equator in spring, and in autumn, is about *seven* days longer than our winter half year. Hence also, one reason for the relative coldness of the southern hemisphere.

Isothermal Bands, and Distribution of Heat over the Globe.

The temperatures are expressed in degrees of Fahrenheit's thermometer; the longitudes are counted from east to west, from the first meridian of the observatory of Paris. The mean temperatures of the seasons have been calculated, so that the months of December, January, and February, form the mean temperature of the winter. The mark * is prefixed to those places, the mean temperatures of which have been determined with the most precision, generally by a mean of 8000 observations. The isothermal curves having a concave summit in Europe, and two convex summits in Asia and Eastern America, the climate is denoted to which the individual places belong:—

Isothermal bands.	Names of the places.	Position in			Mean temperature of the year.	Distribution of Heat in the different Seasons.				Maximum and minimum.	
		Latitude.	Longitude.	Height in feet.		Mean temp. of Winter.	Mean temp. of Spring.	Mean temp. of Summer.	Mean temp. of Autumn.	Mean temp. of warmest month.	Mean temp. of coldest month.
Isothermal band from 32° to 41°.	Nain	57° 8′	63° 40′ W	0	26.8°	— 0.4°	23.7°	48.4°	33.4°	51·8°	—11.2°
	*Enontekies	68 30	18 27 E	1356	27.0	0.4	25.0	54.8	27.4	59.6	— 0.6
	Hospice de St. Gothard	46 30	6 3 E	6390	30.4	18.4	26.4	45.0	31.8	46.2	15.0
	North Cape	71 0	23 30 E	0	32.0	23.8	29.4	43.2	32.2	50.2	22.1
	*Ulea	65 3	23 6 E	0	33.0	11.8	27.2	57.8	36.0	61.6	7.7
	*Umea	63 50	17 56 E	0	33.2	13.0	33.8	54.8	33.4	62.6	11.4
	*Petersburgh	59 56	27 59 E	0	38.8	17.0	38.2	62.0	38.6	65.6	8.6
	Drontheim	63 24	8 2 E	0	40.0	23.8	35.2	61.4	40.1	65.0	19.8
	Moscow	55 45	35 12 E	970	40.2	10.8	44.0	67.1	38.3	70.6	6.0
	Abo	60 27	19 58 E	0	40.4	20.8	38.3	61.8	40.6	—	—
Isothermal band from 41° to 50°.	*Upsal	59 51	15 18 E	0	42.0	25.0	40.0	60.2	42.8	62.4	22.4
	*Stockholm	59 20	15 43 E	0	42.2	25.6	38.3	61.8	43.2	64.0	22.8
	Quebec	46 47	73 30 W	0	41.8	14.2	38·9	68.0	46.0	73.4	13.8
	Christiana	59 55	8 28 E	0	42.8	28.8	40.1	62.6	41.2	66.8	28.8
	*Convent of Peyssenburg	47 47	8 14 E	3066	43.0	28.6	42.0	58.4	43.0	59.4	30.2
	*Copenhagen	55 41	10 15 E	0	45.6	30.8	41.2	62·6	48.4	65.0	27.2
	*Kendal	54 17	5 6 W	0	46.2	36.8	45·2	56.8	46.2	58.1	34.8
	Malouin Islands	51 25	62 19 W	0	47.0	39.6	46.6	53.0	48.4	55.8	37.4
	*Prague	50 5	12 4 E	0	49.4	31.4	47.6	68.9	50.2	—	—
	Gottingen	51 32	7 33 E	456	47.0	30.4	44.2	64.8	48.6	66.4	33.2
	*Zurich	47 22	6 12 E	1350	47.8	29.6	48.2	64.0	48.8	65.7	26.8
	*Edinburgh	55 57	5 30 W	0	47.8	38.6	46.4	58.2	48.4	59.4	38.3
	Warsaw	52 14	18 42 E	0	48.6	27.8	47.4	69.0	49.4	70.4	27.2
	*Coire	46 50	7 10 E	1876	49.0	32.4	55.4	63.4	50.4	64.6	29 6
	Dublin	53 21	8 39 W	0	49.2	39.2	47.3	59.6	50.0	61.0	35.4
	Berne	46 5	5 6 E	1650	49.3	32.0	49.0	66.6	49.8	67 2	30.6
	*Geneva	46 12	3 48 E	1080	49.3	34.9	47.6	65.0	50.0	66.6	34.2
	*Manheim	49 29	6 8 E	432	50.2	33.8	49.6	67.1	49.8	68.8	33.4
	Vienna	48 12	14 2	420	50.6	32.8	51.2	60.2	50.6	70.6	20.6

Isothermal band from 50° to 59°.	*Clermont	45	46	0	45		1260	50·0	34·7	50·6	64·4	51·2	66·2	28·0
	*Buda	47	29	16	41		494	51·0	31·0	51·0	63·2	52·4	71·6	27·6
	Cambridge (U.S.)	42	25	73	23	W	0	50·4	34·0	47·6	64·4	49·8	72·8	29·8
	*Paris	48	50	0	0		222	51·0	38·6	49·2	64·6	51·4	65·3	36·0
	*London	51	30	2	25	W	0	50·4	39·6	48·6	63·2	50·2	61·4	37·8
	Dunkirk	51	2	0	2	E	0	50·6	38·4	48·6	63·8	50·9	64·8	37·8
	Amsterdam	52	22	2	30	E	0	51·6	36·8	51·6	65·8	51·6	67·0	35·4
	Brussels	50	50	2	2	E	0	51·8	36·6	53·2	66·2	51·0	67·4	35·6
	*Franeker	52	36	4	2	E	0	51·8	36·6	51·0	67·2	54·4	69·0	32·9
	Philadelphia	39	56	77	36	W	0	53·4	32·2	51·4	74·0	56·6	77·0	32·7
	New York	40	40	76	18	W	0	53·8	29·8	51·2	79·2	54·6	80·6	25·4
	*Cincinnati	39	6	85	0	W	510	53·8	32·9	54·4	72·8	54·4	74·3	30·2
	St. Malo	48	39	4	21	W	0	54·4	42·2	52·2	66·0	55·8	67·0	41·8
	Nantes	47	13	3	52	W	0	55·0	40·4	54·5	68·6	55·6	70·6	38·0
	Pekin	39	54	114	7	E	0	55·2	26·8	56·3	82·6	54·2	84·4	39·4
	*Milan	45	28	6	51	E	390	55·8	36·4	56·1	73·0	56·8	74·6	36·2
	Bordeaux	44	50	2	54	W	0	56·4	42·0	56·8	70·8	56·3	72·8	41·0
Isothermal band from 59° to 68°.	Marseilles	43	17	3	2	E	0	59·0	45·5	57·6	72·5	60·0	74·6	44·4
	Montpelier	43	36	1	32	E	0	59·4	44·0	57·0	75·8	61·0	78·2	42·0
	*Rome	41	53	10	7	E	0	60·4	45·8	57·8	75·2	62·8	77·0	42·2
	Toulon	43	7	3	30	E	0	62·0	48·4	60·8	74·8	64·4	77·0	46·4
	Nangasachi	32	45	127	35	E	0	60·8	39·4	57·6	83·0	64·2	86·9	37·4
	*Natchez	31	28	93	50	W	180	64·8	48·6	65·4	79·2	65·8	79·7	47·0
Isothermal band from 68° to 77°.	*Funchal	32	37	19	16	W	0	68·6	64·8	65·8	72·5	72·4	75·6	64·2
	Algiers	36	48	0	41	E	0	70·0	61·4	65·6	80·2	72·5	82·8	60·0
Isothermal bands above 77°.	*Cairo	30	2	28	58	E	0	72·4	58·4	73·6	85·1	70·5	85·8	55·8
	*Vera Cruz	19	11	98	21	W	0	77·8	72·0	77·9	81·5	78·6	81·5	71·0
	*Havannah	23	10	84	33	W	0	78·2	71·2	79·0	83·3	79·0	84·0	70·0
	*Cumana	10	27	67	35	W	0	81·8	80·2	83·6	82·0	79·6	84·4	79·2

CLINKSTONE. A stone of an imperfectly slaty structure, which rings like metal when struck with a hammer. Its colour is grey of various shades; it is brittle: as hard as felspar, and translucent on the edges. It occurs in columnar and tabular concretions. Sp. gr. 2.57. Fuses easily into a nearly colourless glass. Its constituents are 57.25 silica, 25.5 alumina, 2.75 lime, 8.1 soda, 3.25 oxide of iron, 0.25 oxide of manganese, and 3 of water.—*Klaproth*. This stone generally rests on basalt. It occurs in the Ochil and Pentland hills, the Bass-rock, the islands of Mull, Lamlash, and Islay, in Scotland; the Breidden hills in Montgomeryshire, and in the Devis mountain, in the county of Antrim. It is found in Upper Lusace and Bohemia.

CLINOMETER. An instrument for measuring the dip of mineral strata. It was originally invented by R. Griffith, Esq. Professor of Geology to the Dublin Society, and subsequently modified by Mr. Jardine and Lord Webb Seymour. See a description and drawing by the latter, in the third volume of the Geological Transactions. Lord Webb's instrument was a very perfect one. It was made by that unrivalled artist, Mr. Troughton.

CLOUD. A mass of vapour, more or less opaque, formed and sustained at considerable heights in the atmosphere, probably by the joint agencies of heat and electricity. The first successful attempt to arrange the diversified forms of clouds, under a few general modifications, was made by Luke Howard, Esq. We shall give here a brief account of his ingenious classification.

The *simple* modifications are thus named and defined: 1. *Cirrus*. Parallel, flexuous, or diverging fibres, extensible in any or in all directions. 2. *Cumulus*. Convex or conical heaps, increasing upwards from a horizontal base. 3. *Stratus*. A widely extended, continuous horizontal sheet, increasing from below.

The *intermediate* modifications which require to be noticed are. 4. *Cirro-cumulus*. Small well-defined roundish masses, in close horizontal arrangement. 5. *Cirro-stratus*. Horizontal, or slightly inclined masses, attenuated towards a part or the whole of their circumference, bent downward, or undulated, separate or in groups, consisting of small clouds having these characters.

The *compound* modifications are, 6. *Cumulo-stratus*. The cirro-stratus, blended with the cumulus, and either appearing intermixed with the heaps of the latter, or superadding a wide-spread structure to its base.

7. *Cumulo-cirro-stratus*, vel *Nimbus*. The rain cloud. A cloud or system of clouds from which rain is falling. It is a horizontal sheet, above which the cirrus spreads, while the cumulus enters it laterally and from beneath.

The *cirrus* appears to have the least density, the greatest elevation, the greatest variety of extent and direction, and to appear earliest on serene weather, being indicated by a few threads pencilled on the sky. Before storms they appear lower and denser, and usually in the quarter opposite to that from which the storm arises. Steady high winds are also preceded and attended by *cirrus* streaks, running quite across the sky in the direction they blow in.

The cumulus has the densest structure, is formed in the lower atmosphere, and moves along with the current next the earth. A small irregular spot first appears, and is as it were the nucleus on which they increase. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps; which may afterwards continue long nearly of the same bulk, or rapidly rise into mountains. They will begin, in fair weather, to form some hours after sunrise, arrive at their maximum in the hottest part of the afternoon, then go on diminishing, and totally disperse about sunset. Previous to rain, the cumulus increases rapidly, appears lower in the atmosphere, and with its surface full of loose fleeces or protuberances. The formation of large cumuli to leeward in a strong wind indicates the approach of a calm with rain. When they do not disappear or subside about sunset, but continue to rise, thunder is to be expected in the night. The *stratus* has a mean degree of density, and is the lowest of clouds, its inferior surface commonly resting on the earth or water. This is properly the cloud of night appearing about sunset. It comprehends all those creeping mists, which in calm weather ascend in spreading sheets, (like an inundation of water), from the bottom of valleys, and the surfaces of lakes and rivers. On the return of the sun, the level surface of this cloud begins to put on the appearance of cumulus, the whole at the same time separating from the ground. The continuity is next destroyed, and the cloud ascends and evaporates, or passes off with the appearance of the nascent cumulus. This has long been experienced as a prognostic of fair weather.

The *cirrus* having continued for some time increasing or stationary, usually passes either to the cirro-cumulus or the cirro-stratus, at the same time descending to a lower station in the atmosphere. This modification forms a very beautiful sky; is frequent in summer, an attendant on warm and dry weather. The *cirro-stratus*, when seen in the distance, frequently gives the idea of shoals of fish. It precedes wind and rain; is seen in the intervals of storms; and sometimes alternates with the cirro-cumulus in the same cloud, when the different evolutions form a curious spectacle. A judgment may be formed of the weather likely to ensue by observing which modification prevails at last. The solar and lunar *haloes*, as well as the parhelion and paraselene, (mock sun and mock moon), prognostics of foul weather, are occasioned by this cloud.

The cumulo-stratus precedes, and the nimbus accompanies, rain. See RAIN.

Mr. Howard gives a view of the origin of clouds, which will be found accompanied with many useful remarks, in the 16th and 17th volumes of the Philos. Magazine.

CLUB-MOSS. *Lycopodium clavatum.* The minute seeds of this are very combustible. When a handful of them is thrown across a flame, they burn explosively; and are therefore used in theatres to imitate the appearance of lightning. By Bucholz's analysis they contain a fixed oil, soluble in alcohol, sugar, and mucilaginous extract, besides insoluble matter.

CLYSSUS. A word formerly used to denote the vapour produced by the detonation of nitre with any inflammable substance.

COAK. Coal is charred in the same manner as wood to convert it into charcoal. An oblong square hearth is prepared by beating the earth to a firm flat surface, and puddling it over with clay. On this, the pieces of coal are piled up, inclining toward one another; and those of the lower strata are set up on their acutest angle, so as to touch the ground with the least surface possible. The piles are usually from 30 to 50 inches high, from 9 to 16 feet broad, and contain from 40 to 100 tons of coal. A number of vents are left, reaching from top to bottom, into which the burning fuel is thrown, and they are then immediately closed with small pieces of coal beaten hard in. Thus the kindled fire is forced to creep along the bottom, and when that of all the vents is united, it rises gradually, and bursts out on every side at once. If the coal contain pyrites, the combustion is allowed to continue a considerable time after the disappearance of the smoke, to extricate the sulphur, part of which will be found in flowers on the surface: If it contain none, the fire is covered up soon after the smoke disappears, beginning at the bottom and proceeding gradually to the top. In 50, 60, or 70 hours, the fire is in general completely covered with the ashes of char formerly made, and in 12 or 14 days the coak may be removed for use. In this way a ton of coals commonly produces from 700 to 1100 pounds of coak.

In this way the volatile products of the coal, however, which might be turned to good account, are lost: but some years ago lord Dundonald conceived and carried into effect a plan for saving them. By burning the coal in a range of 18 or 20 stoves, with as little access of air as may be, at the bottom; and conducting the smoke, through proper horizontal tunnels, to a capacious close tunnel 100 yards or more in length, built of brick, supported on brick arches, and covered on the top by a shallow pond of water; the bitumen is condensed in the form of tar: 120 tons of coal yield about 3½ of tar, though some coals are said to be so bituminous as to afford ⅓ of their weight. Part of the tar is inspissated into pitch, 21 barrels of which are made of 28 of tar; and the volatile parts arising in this process are condensed into a varnish used for mixing with colours for out-door painting chiefly. A quantity of ammonia too is collected, and used for making sal ammoniac. The cakes thus made are likewise of superior quality.

COAL. This very important order of combustible minerals, is divided by professor Jameson into the following species and subspecies:—

Species 1. Brown coal, already described.

Species 2. Black coal, of which there are four sub-species; slate coal, cannel coal, foliated coal, and coarse coal.

1. *Slate coal.* Its colour is intermediate between velvet-black and dark greyish-black. It has sometimes a peacock-tail tarnish. It occurs massive, and in columnar and egg-shaped concretions. It has a resinous lustre. Principal fracture slaty; cross fracture, imperfect conchoidal. Harder than gypsum, but softer than calcareous spar. Brittle. Sp. gr. 1.26 to 1.38. It burns longer than cannel coal; cakes more or less, and leaves a slag. The constituents of the slate coal of Whitehaven, by Kirwan, are 56.8 carbon, with 43.2 mixture of asphalt and maltha, in which the former predominates. This coal is found in vast quantities at Newcastle; in the coal formation which stretches from Bolton, by Allonby and Workington, to Whitehaven. In Scotland, in the river district of Forth and Clyde; at Cannoby, Sanquhar, and Kirconnel, in Dumfriesshire; in Thuringia, Saxony, and many other countries of Germany. It sometimes passes into cannel and foliated coal.

2. *Cannel coal.* Colour between velvet and greyish-black. Massive. Resinous lustre. Fracture flat-conchoidal, or even. Fragments trapezoidal. Hardness as in the preceding sub-species. Brittle. Sp. gr. 1.23 to 1.27. It occurs along with the preceding. It is found near Whitehaven, at Wigan, in Lancashire; Broseley, in Shropshire, near Sheffield; in Scotland, at Gilmerton and Muirkirk, where it is called parrot coal. It has been worked on the lathe into drinking vessels, snuff boxes, &c.

3. *Foliated coal.* Its colour is velvet-black, sometimes with iridescent tarnish. Massive, and in lamellar concretions. Resinous or splendent lustre; uneven fracture; fragments approaching to trapezoidal. Softer than cannel coal; between brittle and sectile. Easily broken. Sp. gr. 1.34 to 1.4. The Whitehaven variety consists, by Kirwan, of 57 carbon, 41.3 bitumen, and 1.7 ashes. It occurs in the coal formations of this and other countries. It is distinguished by its lamellar concretions, splendent lustre, and easy frangibility.

4. *Coarse coal.* Colour dark greyish-black, inclining to brownish-black. Massive, and in granular concretions. Glistening lustre. Fracture, imperfect scaly. Fragments, indeterminate angular. Hardness as above. Easily frangible. Sp. gr. 1.454. It occurs in the German coal formations. To the above, professor Jameson has added *soot coal;* which has a dark greyish-black colour; is massive; with a dull semi-metallic lustre. Fracture uneven; sometimes earthy. Shining streak; soils; is soft, light, and easily frangible. It burns with a bituminous smell, cakes, and leaves a small quantity of ashes. It occurs along with slate-coal in West-Lothian and the Forth district; in Saxony and Silesia.

Species 3d. *Glance-coal,* of which the professor gives two sub-species, pitch-coal and glance-coal. 1. *Pitch-coal.* Colour velvet-black. Massive, or in plates and botroidal branches, with a woody texture. Splendent and resinous. Fracture large, perfect conchoidal. Fragments sharp-edged and indeterminate angular; opaque; soft; streak brown-coloured. Brittle. Does not soil. Sp. gr. 1.3. It burns with a greenish flame. It occurs along with brown coal in beds, in floetz, trap, and limestone rocks, and in bituminous shale. It is found in the isles of Sky and Faroe; in Hessia, Bavaria, Bohemia, and Stiria. It is used for fuel, and for making vessels and snuff-boxes. It is called black amber in Prussia, and is cut into rosaries and necklaces. It is distinguished by its splendent lustre and conchoidal fracture. It was formerly called *jet,* from the river Gaga in Lesser Asia.

2. *Glance-coal;* of which we have four kinds, conchoidal, slaty, columnar, and fibrous. The conchoidal has an iron-black colour, inclining to brown, with sometimes a tempered steel tarnish. Massive and vesicular. Splendent, shining and imperfect metallic lustre. Fracture flat conchoidal; fragments sharp-edged. Hardness as above. Brittle, and easily frangible. In thin pieces, it yields a ringing sound. It burns without flame or smell, and leaves a white-coloured ash. Its constituents are 96.66 inflammable matter, 2 alumina, and 1.38 silica and iron. It occurs in beds in clay-slate, grey-wacke, and alum-slate; but it is more abundant in secondary rocks, as in coal and trap formations. It occurs in beds in the coal formations of Ayrshire, near Cumnock and Kilmarnock; in the coal district of the Forth; and in Staffordshire. It appears to pass into slaty glance-coal.

Slaty glance-coal. Colour iron-black. Massive. Lustre shining, and imperfect metallic. Principal fracture slaty; coarse fracture, imperfect conchoidal. Fragments trapezoidal. Softer than conchoidal glance-coal. Easily frangible; between sectile and brittle. Sp. gr. 1.50. It burns without flame or odour. It consists, by Dolomieu, of 72.05 carbon, 13.19 silica, 3.29 alumina, 3.47 oxide of iron, and 8 loss. It occurs in beds or veins of different rocks. In Spain, in gneiss; in Switzerland, in mica-slate and clay-slate; in the trap rock of the Calton-hill, Edinburgh; in the coal formations of the Forth district. It is found also in the floetz districts of Westcraigs, in West-Lothian, Dunfermline, Cumnock, Kilmarnock, and Arran; in Brecknock, Caermarthenshire, and Pembrokeshire, in England; and at Kilkenny, Ireland; and abundantly in the United States. In this country it is called blind coal.

Columnar glance-coal. Colour velvet-black and greyish-black. Massive, disseminated, and in prismatic concretions. Lustre glistening, and imperfect metallic. Fracture conchoidal. Fragments sharp-edged. Opaque. Brittle. Sp. gr. 1·4. It burns without flame or smoke. It forms a bed several feet thick in the coal-field of Sanquhar, in Dumfries-shire; at Saltcoats, in Ayrshire, it occurs in beds and in green-stone; in basaltic columnar rows near Cumnock, in Ayrshire.

Fibrous coal. Colour dark greyish-black. Massive, in thin layers, and in fibrous concretions. Lustre glimmering, or pearly. It soils strongly. It is soft, passing into friable. It burns without flame; but some varieties scarcely yield to the most intense heat. It is met with in the different coal fields of Great Britain. Its fibrous concretions and silky lustre distinguish it from all the other kinds of coal.

It is not certain that this mineral is wood mineralized. Several of the varieties may be original carbonaceous matter, crystallized in fibrous concretions.—*Jameson.*

Parts.		Charcoal.	Earth.
100	Kilkenny coal contain	97.3	3.7
	Anthracite, - -	90.0	10.0
	Ditto, - - -	72.0	20.0
	Ditto, - - -	97.25	2 7
Coal of Notre Dame de Vaux,		78.5	20.

The following table exhibits the results of Mr. Mushet's experiments on the carbonization and incineration of coals:—

	Volatile matter.	Charcoal.	Ashes.	Sp. gr. of coal.	Sp. gr. of coak.
Welsh furnace coal,	8.50	88.068	3.432	1.337	1.
Alfreton do. do.	45.50	52.456	2.044	1.235	less than 1.
Butterly do. do.	42.83	52.882	4.288	1.264	1.1
Welsh stone do.	8.00	89.700	2.300	1.368	1.39
Welsh slaty do.	9.10	84.175	6.725	1.409	
Derbyshire cannel do.	47.00	48.362	4.638	1.278	
Kilkenny coal,	4.25	92.877	2.873	1.602	1.657
Stone-coal found under basalt,	16.66	69.74	13.600		
Kilkenny slaty coal,	13.00	80.475	6.525	1.443	
Scotch cannel coal,	56.57	39.430	4.000		
Bonlavooneen do. } Irish,	13.80	82.960	3.240	1.436	1.596
Corgee coal } Irish,	9.10	87.491	3.409	1.403	1.656
Queen's County, No. 39. } Irish,	10.30	86.560	3.140	1.403	1.622
Stone-wood, Giant's Causeway,	33.37	54.697	11.933	1.150	
Oak wood,	80.00	19.500	0.500		

It was remarked long ago by Macquer, that nitre detonates with no oily or inflammable matter, until such matter is reduced to coal, and then only in proportion to the carbonaceous matter it contains. Hence it occurred to Mr. Kirwan, that as coals appear in distillation to be for the most part merely compounds of carbon and bitumen, it should follow, that by the decomposition of nitre, the quantity of carbon in a given quantity of every species of coal may be discovered, and the proportion of bitumen inferred. This celebrated chemist accordingly projected on a certain portion of nitre in a state of fusion, successive fragments of various kinds of coal, till the deflagration ceased. Coal, when in *fine* powder, was thrown out of the crucible. The experiments seem to have been judiciously performed, and the results are therefore entitled to as much confidence as the method permits. Lavoisier and Kirwan state, that about 13 parts of dry wood charcoal decompose 100 of nitre.

100 parts	Charcoal.	Bitumen.		Earth.	Sp. gr.
Kilkenny coal,	97.3	0		3.7	1.526
Comp. cannel,	75.2	21.68	maltha	3.1	1.232
Swansey,	73.53	23.14	mixt.	3.33	1.357
Leitrim,	71.43	23.37	do.	5.20	1.351
Wigan,	61.73	36.7	do.	1.57	1.268
Newcastle,	58.00	40 0	do.	—	1.271
Whitehaven,	57.0	41.3		1.7	1.257
Slaty cannel,	47.62	32.52	mal.	20.0	1.426
Asphalt,	31.0	68.0	bitumen	—	1.117
Maltha	8.0			—	2.07

100 parts of the best English coal give, of coak, . . . 63. by Mr. Jars.
100 do. . . . 73. Hielm.
100 do. Newcastle do. 58. Dr. Watson.

Mr. Kirwan says he copied the result, for Newcastle coal, from Dr. Watson.

The foliated or cubical coal, and slate coal, are chiefly used as fuel in private houses; the caking coals, for smithy forges; the slate coal, from its keeping open, answers best for giving great heats in a wind furnace, as in distillation on the great scale; and glance coal is used for drying grain and malt. The coals of South Wales contain less volatile matter than either the English or the Scotch; and hence, in equal weight, produce a double quantity of cast iron in smelting the ores of this metal. It is supposed that 3 parts of good Newcastle coals are equivalent, as fuel, to 4 parts of good Scotch coals.

Werner has ascertained three distinct coal formations, without including the beds of coal found in sandstone and limestone formations. The first or oldest formation, he calls the independent coal formation, because the individual depositions of which it is composed, are independent of each other, and are not connected. The second is that which occurs in the newest floetz-trap formation; and the third occurs in alluvial land. Werner observes, that a fourth formation might be added, which would comprehend peat and other similar substances; so that we would have a beautiful and uninterrupted series, from the oldest formation to the peat, which is daily forming under the eye.

The *independent* formation contains exclusively coarse coal, foliated coal, cannel coal, slate coal, a kind of pitch coal, and slaty glance coal. The latter was first found in this formation in Arran, Dumfries-shire, Ayrshire, and at Westcraigs, by Professor Jameson. The formation in the newest floetz-trap contains distinct pitch coal, columnar coal, and conchoidal glance coal. The alluvial formation contains almost exclusively earth coal and bituminous wood. The first formation, besides coal, contains three rocks which are peculiar to it; these are a conglomerate, which is more or less coarse-grained; a friable sandstone, which is always micaceous; and lastly, slate-clay. But besides these, there occur also beds of harder sandstone, marl, limestone, porphyritic stone, bituminous shale, clay-ironstone; and, as discovered by Professor Jameson, greenstone, amygdaloid, and graphite. The slate-clay is well characterized by the great variety of vegetable impressions of such plants as flourish in marshes and woods. The smaller plants and reeds occur in casts or impressions always laid in the direction of the strata; but the larger arborescent plants often stand erect, and their stems are filled with the substance of the superincumbent strata, which seems to show that these stems are in their original position. The leaves and stems resemble those of palms and ferns. The central, northern, and western coal mines of England; the river coal districts of the Forth and the Clyde, and the Ayrshire, and in part the Dumfries-shire coals, belong to this formation, as well as the coals in the northern and western parts of France.

By far the most valuable and extensive beds of coal which have been found and wrought are in Great Britain. The general form of our great independent coal-beds is semi-circular, or semi-elliptical, being the segment of a great basin. The strata have a dip or declination to the horizon of from 1 in 5 to 1 in 20. They are rarely vertical, and seldom perfectly horizontal to any considerable extent. Slips and dislocations of the strata, however, derange more or less the general form of the basin.

Those who wish to understand the most improved modes of working coal mines, will be amply gratified by consulting, *A Report on the Leinster Coal District*, by Richard Griffith, Esq. Professor of Geology, and Mining Engineer to the Dublin Society. The author has given a most luminous view of Mr. Buddle's ingenious system of working and ventilating, in which from 7-8ths to 9-10ths of the whole coal may be raised, instead of only ⅓, which was the proportion obtained in the former modes. Mr. Griffith has since published some other reports, the whole constituting an invaluable body of mining information.

COAL GAS. When coal is subjected in close vessels to a red heat, it gives out a vast quantity of gas, which being collected and purified, is capable of affording a beautiful and steady light, in its slow combustion through small orifices. Dr. Clayton seems to have been the first who performed this experiment, with the view of artificial illumination, though its application to economical purposes was unaccountably neglected for about 60 years. At length Mr. Murdoch of the Soho Foundry, instituted a series of judicious experiments on the extrication of gas from ignited coal; and succeeded in establishing one of the most capital improvements which the arts of life have ever derived from philosophical research and sagacity.

In the year 1798, Mr. Murdoch, after several trials on a small scale five years before, constructed, at the foundry of Messrs. Bolton and Watt, an apparatus upon a large scale, which during many successive nights was applied to the lighting of their principal building; and various new methods were practised of washing and purifying the gas. In the year 1805, the cotton-mill of Messrs. Philips and Lee, reckoned the most extensive in the kingdom, was partly lighted by gas under Mr. Murdoch's direction; and the light was soon extended over the whole manufactory. In the same year, I lighted up the large lecture-room of Anderson's Institution with coal-gas, generated in the laboratory; and continued the illumination every evening through that and the succeeding winter. Hence I was induced to pay particular attention to the theory and practice of its production and use.

If coal be put into a cold retort and slowly exposed to heat, its bitumen is merely volatalized in the state of condensible tar. Little gas, and that of inferior illuminating power, is produced. This distillatory temperature may be estimated at about 600° or 700° F. If the retort be previously brought to a bright cherry-red heat, then the coals, the instant after their introduction, yield a copious supply of good gas, and a moderate quantity of tarry and ammoniacal vapour. But when the retort is heated to nearly a white incandescence, the part of the gas richest in light is attenuated into one of inferior quality, as I have shown in detailing Berthollet's experiments on CARBURETTED HYDROGEN. A pound of good cannel coal, properly treated in a small apparatus, will yield 5 cubic feet of gas, equivalent in illuminating power to a mould candle six in the pound. See CANDLE.

On the great scale, however, 3½ cubic feet of good gas are all that should be expected from 1 pound of coal. A gas jet, which consumes half a cubic foot per hour, affords a steady light equal to that of the above candle.

According to Mr. Murdoch's statement, presented to the Royal Society, 2500 cubic feet of gas were generated in Mr. Lee's retort from 7 cwt. = 784 lbs. of cannel coal. This is nearly 3⅕ cubic feet for every pound of coal, and indicates judicious management. The price of the best Wigan cannel is 13½*d.* per cwt. (22*s.* 6*d.* per ton) delivered at Mr. Lee's mill at Manchester; or about 8*s.* for the seven hundred weight. About ⅓ of the above quantity of good common coal, at 10*s.* per ton, is required for fuel to heat the retorts. Nearly ⅔ of the weight of the coal remains in the retort in the form of coak, which is sold on the spot at 1*s.* 4*d.* per cwt. The quantity of tar produced from each ton of cannel coal, is from 11 to 12 ale gallons.

The economical statement for one year is given by Mr. Murdoch thus:—

Cost of 110 tons of cannel coal,	£. 125
Ditto of 40 tons of common ditto,	20
	145
Deduct the value of 70 tons of coak,	93
The annual expenditure in coal, without allowing any thing for tar, is -	52
And the interest of capital, and wear and tear of apparatus, - - -	350
Making the total annual expense of the gas apparatus about - -	600
That of candles to give the same light,	2000
If the comparison had been made upon an average of three hours per day, instead of two hours, (all the year round), then the cost from gas would be only - - - -	650
Ditto candles, - - -	3000

The peculiar softness and clearness of this light, with its almost unvarying intensity, soon brought it into great favour with the work-people. And its being free from the inconvenience and danger resulting from the sparks and frequent snuffing of candles is a circumstance of material importance, tending to diminish the hazard of fire, and lessening the high insurance premium on cotton-mills. The cost of the attendance upon candles would be fully more than upon the gas apparatus; and upon lamps greatly more, in such an establishment as Mr. Lee's. The preceding statements are of standard authority, far above the suspicion of empiricism or exaggeration, from which many subsequent statements by gas book compilers are by no means exempt.

At the same manufactory, Dr. Henry has lately made some useful experiments on the quality of the gas disengaged from the same retort at different periods of the decomposition. I have united in the following table, the chief part of his results. He collected in a bladder the gas, it issued from an orifice in the pipe, between the retorts and the tar pit; and purified it afterwards by agitation in contact of quicklime and water. Ten cwt. or 1120 lbs. of coal were contained in the retorts.

	Hours from commencement.	100 measures of impure gas contain,		100 measures of purified gas contain,			100 measures of purified gas.		100 combustible gas, exclusive of azote.	
		Sulph. hydr.	Carb. acid.	Olef.	Other infl. gases.	Azote	Cons. oxyg.	Give car. ac.	Take oxyg.	Carb. acid.
Wigan cannel.	½	0½	5½	16	64	20	180	94	225	118
	1	3	3½	18	77¼	4¾	210	112	220	117
	3	2½	2½	15	80	5	200	108	210	114
	5	2½	2½	13	72	15	176	94	206	108
	7	2	2½	9	76	15	170	83	200	98
	9	0½	2½	8	77	15	150	73	176	85
	10½	0	2	6	74	20	120	54	150	70
	12	0	0½	4	76	20	82	36	103	45
Common coal from Clifton.	1	3	3	10	90	0	164	91	164	91
	3	2	2	9	91	0	168	93	168	93
	5	3	2	6	94	0	132	70	132	70
	7	1	3	5	80	15	120	64	140	75
	9	1	2½	2	89	9	112	60	123	66
	11	1	1	0	85	15	90	43	106	50

Dr. Henry conceives *that* gas to have the greatest illuminating power, which, in a given volume, consumes the largest quantity of oxygen; and that hence the gas of cannel coal is one-third better than the gas from common coal. 3500 cubic feet of gas were collected from 1120 pounds of the cannel coal; and only 3000 from the same weight of the Clifton coal.

From the preceding table we see also, that the gas which issues at the third hour contains, in 100 parts, of sulphuretted hydrogen and carbonic acid, each 2½, of azote 4¾, olefiant gas 14½, and of other inflammable gases 76 parts.

A cubic foot of carbonic acid weighs 800 gr. A cubic foot of sulphuretted hydrogen weighs 620. The first takes about 1026 gr. of lime for its saturation; the second about 1070; and hence 1050, the quantity assigned by Dr. Henry for either, is sufficiently exact. 100 cubic feet of the above impure gas, containing 5 cubic feet of these two gases, will require at least 2100 grains of lime, or about 5 oz. avoirdupois for their complete condensation.

The proportion employed by Mr. Lee is, 5 pounds of fresh burned lime to 200 cubic feet of gas. The lime, after being slaked, is sifted and mixed with a cubic foot (7.48 wine gallons) of water. This quantity of cream of lime is adequate to the ordinary purification of the gas. Yet it will still slightly darken a card, coated with moistened white lead. A second exposure to lime makes it absolutely pure.

Measures.	Oxygen.	Carb. ac.
100 crude gas, consume	190	give 108
100 gas, once washed,	175	100
100 do. twice washed,	175	100

What is separated by the first washing is probably vapour of bitumen or petroleum, which would injure the pipes by its deposition, more than it would profit by any increased quantity of light. Though we thus see that the second washing in the above experiment condensed none of the olefiant gas, it is prudent not to use unnecessary agitation with a large body of water.

The carbonate of lead precipitated from a cold solution of the acetate, by carbonate of ammonia, washed with water, and mixed with a little of that liquid into the consistence of cream, is well adapted to the separation of sulphuretted hydrogen from coal gas. The carbonic acid may then be withdrawn from the residuary gas, by a little water of potash. We must now determine the azote present, which is easily done by firing a volume of this gas with thrice its volume of pure oxygen. What remains after agitation with water of potash, is a mixture of azote and oxygen. Explode it with hydrogen; one-third of the diminution of volume shows the oxygen; the rest is azote. We have now to eliminate three quantities, viz. the volume of olefiant gas, that of common carburetted hydrogen, and that of carbonic oxide. Mr. Faraday has proved that chlorine acts pretty speedily on the second species of carburetted hydrogen, and therefore it cannot be employed with the view of condensing merely the first species. In contact with moisture, chlorine acts also rapidly on carbonic oxide, giving birth to muriatic and carbonic acids. If we be therefore deprived of all known means of *chemical* elimination, we shall find a ready and successful resource in the doctrines of specific gravity. In any mixture of two solids, two liquids, or two gases, whose specific gravities are known, it is easy to infer from the specific gravity of the compound (when the mixture is effected without change of volume) the relative weights of the two constituents. Thus if we apply to an alloy of gold and zinc the old problem of Archimedes, we shall determine exactly the proportion of each metal present, because the volume of the alloy is very nearly the sum of the volumes of its ingredients. I have long applied this problem to gaseous mixtures, and found it a very convenient means of verification on many occasions, particularly in examining the nature of the residuary air in the lungs of the galvanized criminal, of which an account is given in the 12th Number of the Journal of Science.

Problem.—*In 100 measures of mixed gases, consisting, for example, of olefiant gas, carbonic oxide, and subcarburetted hydrogen, in unknown proportions, to determine the quantity of each.* The first step is to find the quantity of the two denser gases, which have the same specific gravity $= 0.9720$.

Rule.—Multiply by 100, the difference between the specific gravity of the mixture and that of the lighter gas. Divide that number, by the sum of the differences of the sp. gr. of the mixture, and that of the denser and lighter gas; the quotient is the *per-centage* of the denser. *See Gregory's Mechanics*, vol. i. p. 364.

Example.—A mixture of olefiant gas, carbonic oxide, and subcarburetted hydrogen, has a sp. gr. of 0.638.

What is the proportion *per cent.* of the first two?

Sp. gr. of subcarb. hydrogen is 0.555; $0.638 - 0.555 = 0.083 \therefore 100 \times 0.083 = 8.3$

$$\left.\begin{array}{l} 0.972 \\ 0.638 \\ 0.555 \end{array}\begin{array}{l} \text{difference } 0.334 \\ \text{difference } 0.083 \end{array}\right. \text{sum} = 0.417$$

And $\frac{8.3}{0.417} = 20 =$ volume of the two heavier gases; and therefore there are 80 of the lighter gas. Hence, having fired the whole with oxygen, we must allow 160 of oxygen, for saturating the 80 measures of the subcarburetted hydrogen. Then let us suppose 35 cubic inches more oxygen to have been consumed. We know that the saturating power of olefiant gas, and of carbonic oxide with oxygen, is in the ratio of 3 to 0.5. Therefore, the quantity of olef. gas. $= \frac{35-(20 \times 0.5)}{3-0.5} = \frac{25}{2.5} =$ 10 measures.

We see now, that a gas of sp. gr. 0.638 consists of

0.8	measures	subcarb. hydrogen	=	0.444
0.1	do.	olefiant gas	=	0.097
0.1	do.	carb. oxide	=	0.097
				0.638

For further details, see Gas.

Dr. Henry gives, at the end of his experiments, (Manchester Memoirs, vol. iii. second series), some hypothetical representations of the constitution of coal gases, in one of which he assigns, 2 of carburetted hydrogen,
2 of carbonic oxide,
and 15 of pure hydrogen, in $18\frac{2}{3}$ measures.

With mixtures of *three* gaseous bodies, the problem of eliminating the proportion of the constituents by explosion with oxygen, becomes complex, and several hypothetical proportions may be proposed. But I can hardly imagine, that pure hydrogen should be disengaged from ignited coal. There is no violation of the doctrine of multiple proportions, in conceiving a compound to exist in which three or more atoms of hydrogen may be united with one of carbon. Berthollet's experiments render this view highly probable. If the above hypothetical numbers were altered to 1.6; 2.4; and 15; their accordance with Dr. Henry's experiments would be improved. Now, this is a considerable latitude of adjustment.

The principles laid down at the commencement of this article show, that the more uniformly the coal undergoes igneous decomposition, the richer is the gas. The retorts, if *cylindrical*, should not exceed, therefore, 12 or 14 inches diameter, and six or seven feet in length. Compressed cylinders, whose length is 4½ feet, breadth 2 feet, and inside vertical diameter about 10 inches, have been found to answer well at Glasgow. The cast iron of which they are composed must be screened from the direct impulse of the fire by a case of firebrick.

On the maximum quantity of gas procurable from coal, it is difficult to acquire satisfactory information at the great gas establishments. Exaggeration seems to be the prevailing foible. Mr. Accum gives the following tables, as the maximum results of his own experiments, made at the Royal Mint gas works:—

One chaldron = 27 cwt. of coal produces,

		Cubic feet of gas.
Scotch cannel coal,		19.890
Lancashire Wigan cannel,		19.608
Yorkshire cannel, Wakefield,		18.860
Staffordshire coal,	1st variety,	9.748
By experim. at Birmingham gas-works,	2d do.	10.223
	3d do.	10.866
	4th do.	9.796
Gloucestershire coal,	High Delph,	16.584
do.	Low Delph,	12.852
do.	Middle Delph,	12.096
Newcastle coal,	Hartley,	16.120
	Cowper's High Main,	15.876
	Tanfield Moor,	16.920
	Pontops,	15.112

The following varieties of coal, according to Mr. Accum, contain a less quantity of bitumen, and a larger quantity of carbon than the preceding. They soften, swell, and cake on the fire, and are well calculated for the production of coal gas:—

One chaldron produces,

Newcastle coal,	Russel's Wall's-end,	16.876
	Bewicke and Crastor's Wall's-end,	16.897
	Heaton Main,	15.876
	Bleyth,	12.096
	Elden Main,	9.600
	Primrose Main,	8.348

Concerning the *duration* of the decomposition of a retort-charge of one cwt. various opinions are maintained. Mr. Peckston's experiments at the Gas-light and Coak Company's works, Westminster station, seem to prove, that decided advantages attend the continuance of the process for eight hours, in preference to six, or any shorter period. The average product of gas, from one chaldron of Newcastle coals, at six hours' charges, he states at 8300 cubic feet, and at those of eight hours, at 10,000. On 76 retorts worked for a week at the latter rate, he gives a statement to prove, that there is a saving of £77. 18s. above the former rate of working. Two men, one by day, and one by night, can attend nine or ten retorts, at eight hour charges, of 100 pounds of coal each.

Scotch cannel yields its gas most readily, or	1·00
Newcastle coal,	1·04
Gloucester Low Delph,	1·08
Newcastle, Brown's Wall's-end,	1·18
Warwickshire,	1·65

Hence, the latter kinds afford good gas, long after the former are exhausted.

The following table, by Mr. Peckston, exhibits the ratio at which the gas is evolved from Bewicke and Crastor's Wall's-end, coal, when the retorts are worked at eight hours' charges:—

	Cubic feet.	Sum.
During the 1st hour are generated,	2000	
2d,	1495	3495
3d,	1387	4882
4th,	1279	6161
5th,	1189	7350
6th,	991	8341
7th,	884	9225
8th,	775	10000

We have already explained the principles of purifying gas by milk of lime. But previous to its agitation with that liquid, it should be made to traverse a series of refrigeratory pipes submersed under cold water. A vast variety of apparatus, some very ingenious, but many absurd, have been contrived within these few years, for exposing gas to lime in the liquid or dry state. Mr. Accum and Mr. Peckston have been at much pains in describing several of them. The gas-holder is now generally preferred of a cylindrical shape, like an immense drum, open at bottom; and flat, or slightly conical at top. The diameter is from 33 to 45 feet in the large establishments, and the height from 16 to 24. The average capacity is from 15·000 to 20·000 cubic feet. It is suspended in a tank of water by a strong iron chain fixed to the centre of its summit, which, passing round a pulley, bears the counterweight. When totally immersed in water, the sheet-iron, of which the gas-holder is composed, loses hydrostatically about two-fifteenths of its weight; or if equipoised when immersed, it becomes two-fifteenths heavier when in air, *minus* the buoyancy of the included gas. The mean sp. gr. of well purified coal-gas by Dr. Henry's late experiments may be computed at 0·676, to air called 1·000; or in round numbers, its density may be reckoned two-thirds of that of air. One cubic foot of air weighs 527 gr., one cubic foot of gas weighs 351 gr.; the difference is 176 gr. Hence, 40 cubic feet have a buoyancy of one pound avoirdupois.

The hydrostatic compensation is obtained by making the weight of that length of the suspending chain which is between the top of the immersed gasometer and the tangential point of the pulley-wheel, equal to *one-fifteenth* the weight of the gasometer in pounds, minus its capacity in cubic feet, divided by twice 40, or 80. Thus, if its weight be 4 tons, or 8960 lbs., and its capacity 15000 cubic feet, a length of chain equal to the height of the gasometer, or to its vertical play, should weigh 597 lbs., without allowing for buoyancy. In this case, the gasometer, when out of water, would have the buoyancy of that liquid, replaced by the passage of these 597 lbs. to the opposite side of the wheel-pulley, so that twice that weight =1194 lbs. would then be added to the constant counterpoise. When the gasometer again sinks, and loses its weight by the displacement of the liquid, successive links of the chain come over above it, augmenting its weight, and diminishing that of the counterpoise by a twofold operation, as in taking a weight out of one scale, and putting it in the other.

But we must now introduce the correction for the buoyancy of the combustible gas. In ordinary cases we must regard it as holding a portion of petroleum vapour diffused through it, and cannot fairly estimate its sp. gravity at less than 0·750; whence nearly 50 cubic feet have a buoyancy of one pound over the same bulk of atmospheric air. If we divide 15000 by 50, the quotient =300 is the double of what must be deducted in pounds weight from the hydrostatic compensation. Thus 597 — 150 = 447, is the weight of the above portion of chain. When the gasometer attains its greatest elevation, these 447 lbs. hang on the opposite side of the wheel, constituting an increased counterpoise of twice 447=894, to which, if we add the total buoyancy of the included gas = 300 lbs. we have the sum 1194, equal to the total increase of the weight of the iron vessel on its suspension in air.

The principles of the distribution of gas are exhibited in the following table given by Mr. Peckston. The gas-holder is worked at a pressure of one vertical inch of water, and each argand burner consumes five cubic feet per hour.

Inter. diamr. of pipe in inches.	Cubic feet passing per hour.	Burners supplied.
2/8	20	4
3/8	50	10
4/8	90	18
5/8	160	32
6/8	250	50
7/8	380	76
1	500	100
2	2000	400
3	4500	900
4	8000	1600
5	12500	2500
6	18000	3600
7	24500	4900
8	32000	6400
9	40500	8100
10	50000	10000
12	72000	14400
14	98000	19·600
16	128000	25·600
18	162000	32·400

The following statement is given by Mr. Accum. An argand burner, which measures in the upper rim half an inch in diameter between the holes from which the gas issues, when furnished with five apertures 1-25th part of an inch diameter, consumes two cubic feet of gas in an hour, when the gas flame is one and a half inch high. The illuminating power of this burner is equal to three tallow candles eight in the pound.

An argand burner three-fourths of an inch in diameter as above, and perforated with holes 1-30th of an inch diameter (what number? probably 15) consumes three cubic feet of gas in an hour, when the flame is 2¼ inches high, giving the light of four candles eight to the pound. And an argand burner seven-eighths of an inch diameter as above, perforated with 18 holes 1-32d of an inch diameter, consumes, when the flame is three inches high, four cubic feet of gas per hour, producing the light of six tallow candles eight to the pound. Increased length of flame makes imperfect combustion, and diminished intensity of light. And if the holes be made larger than 1-25th of an inch, the gas is incompletely burnt. The height of the glass chimney should never be less than five inches.

The argand burner, called No. 4, when burnt in shops from sunset till nine o'clock, is charged three pounds a-year. The diameter of its circle of holes is five-eighths of an inch, and of each hole 1-32d of an inch. It is drilled with 12 holes, 5-32ds of an inch from the centre of one to the centre of another. Height of this burner 1¼ inches.

No. 6. argand burner. 15 apertures of

1-32d of an inch; diameter of their circle three-fourths of an inch; height of burner two inches: charge per annum four guineas.

According to Mr. Accum, one gas lamp, consuming 4 cubic feet of gas in an hour, if situated 20 feet distant from the main which supplies the gas, requires a tube not less than a quarter of an inch in the bore; 2 lamps, 3 feet distance, require a tube three-eighths of an inch; 3 lamps, 30 feet distance, require a tube three-eighths; 4 lamps, at 40 feet, one-half inch bore; 10 lamps, at 100 feet distance, require a tube three-fourths of an inch; and 20, 150 feet distant, 1¼ inch bore.

We have seen that the average product in London from 1 pound of coal in 8 hours, is 3½ cubic feet. In the Glasgow coal gas establishment, which is conducted by engineers skilled in the principles of chemistry and mechanics, fully 4 cubic feet of gas are extracted from every pound of coal of the splent kind in 4 hour charges, from retorts containing each 120 lbs.; which is about two-thirds of their capacity. The decomposing heat is much the same as that used in London, but the retorts are compressed cylinders, a little concave below. Hence in 8 hours, fully double the London quantity of gas is obtained from a retort in Glasgow.

An ingenious pupil of mine, lately employed by a projected gas company in Glasgow to visit the principal factories of gas in England, made a series of accurate experiments on its illuminating quality in the different towns. For this purpose, he carried along with him a mould candle, six in the pound, and a single-jet gas-nozzle. By attaching this to a gas-pipe, and producing a flame of determinate length, (three inches), he could then, by the method of shadows, compare the flame of the gas with that of his candle, and ascertain their relative proportions of light. He found that the average illuminating power of the gas in the English establishments, was to that of the Glasgow company as four to five; the worst being so low as three to five, and the best, as five to six. If we therefore multiply this ratio, into the double product of gas obtained in the Glasgow gas-work, we shall have the proportion of light generated here, and in London, from an equal-sized retort, in an equal time, as 100 to 40. This result merits entire confidence. In the sequel of the article LIGHT, in this Dictionary, instructions will be given how to calculate the relative illuminating powers of different flames.

When the tar is passed through ignited iron pipes, it yields from 10 to 15 cubic feet of gas per pound. The deposit of refractory asphaltum, however, is very apt to obstruct the pipes; and the light afforded is perhaps of inferior quality. Hence tar is decomposed in very few establishments.

The film of petroleum, which floats on the water of the gasometer tank, and that procured from the tar by distillation, have been used instead of oil for street-lamps. The lamp fountain is kept on the outside of the glass lantern, and the flame is made small, to prevent an explosion of the vaporized naphtha.

1430 lbs. of tar by boiling yield nine cwt. of good pitch. From a chaldron of Newcastle coal about 200 lbs. of ammoniacal liquor are obtained; a solution chiefly of the carbonate and sulphate. The strongest liquor comes from the caking coal. A gallon, or 8½ lbs. usually requires for saturation from fifteen to sixteen ounces of oil of vitriol, sp. gr. 1·84. To obtain subcarbonate of ammonia, 125 lbs. of calcined gypsum in fine powder are added to 108 gallons of the ammoniacal liquor. The mixture is stirred, and the cask containing it is then closed for three or four hours. Sixteen ounces of sulphuric acid are now mixed in; and the whole allowed to remain at rest for four or six hours. The supernatant sulphate of ammonia is next evaporated till it crystallize. One hundred weight of the dry crystals is mixed with about their weight of dry chalk in powder, and sublimed from a cylindrical iron retort into a barrel-shaped receiver of lead. A charge of 120 lbs. of the mixture is usually decomposed in the course of twenty-four hours. One hundred weight of dry sulphate of ammonia is said to produce from sixty to sixty-five pounds of solid subcarbonate of ammonia. If the sulphate of ammonia, mixed with common salt, is exposed to a subliming heat, sal ammoniac is obtained. For Oil Gas, see OIL.

COATING, or LORICATION. Chaptal recommends a soft mixture of marly earth, first soaked in water, and then kneaded with fresh horse-dung, as a very excellent coating.

The valuable method used by Mr. Willis of Wapping to secure or repair his retorts used in the distillation of phosphorus, deserves to be mentioned here. The retorts are smeared with a solution of borax, to which some slaked lime has been added, and when dry, they are again smeared with a thin paste of slaked lime and linseed oil. This paste being made somewhat thicker, is applied with success, during the distillation, to mend such retorts as crack by the fire.

COBALT. A brittle, somewhat soft, but difficultly fusible metal, of a reddish grey colour, of little lustre, and a sp. gr. of 8.6. Its melting point is said to be 130° Wedgewood. It is generally associated in its ores with nickel, arsenic, iron, and copper; and the cobalt of commerce usually contains a proportion of these metals. To separate them, calcine with 4 parts of nitre, and wash away, with hot water, the soluble arseniate of potash. Dissolve the residuum in dilute nitric acid, and immerse a plate of iron in the solution, to precipitate the copper. Filter the liquid, and evaporate to dryness. Digest the mass with water of ammonia, which will dissolve only the oxides of nickel and cobalt. Having expelled the excess of alkali by a gentle heat from the clear ammoniacal solution, add cautiously water of potash, which will precipitate the oxide of nickel. Filter immediately, and boil the liquid, which will throw down the pure oxide of cobalt. It is reduced to the metallic state by ignition in contact with lamp-black and oil. Mr. Laugier treats the above ammoniacal solution with oxalic acid. He then redissolves the precipitated oxalates of nickel and cobalt in concentrated water of ammonia, and exposes the solution to the air. As the ammonia exhales, oxalate of nickel, mixed with ammonia, is deposited. The nickel is entirely separated from the liquid by repeated crystallizations. There remains a combination of oxalate of cobalt and ammonia, which is easily reduced by charcoal to the metallic state. The small quantity of cobalt remaining in the precipitated salt of nickel, is separated by digestion in water of ammonia.

Cobalt is susceptible of magnetism, but in a lower degree than steel and nickel.

Oxygen combines with cobalt in two proportions; forming the dark blue protoxide, and the black deutoxide. The first dissolves in acids without effervescence. It is procured by igniting gently in a retort the oxide precipitated by potash from the nitric solution. Proust says, the first oxide consists of 100 metal + 19.8 oxygen; and Rothoff makes the composition of the deutoxide 100 + 36.77. If we call the first 18.5, and the second 37, then the prime equivalent of cobalt will be 5.4; and the two oxides will consist of

Protox.	Cobalt,	5.4	100	84.38
	Oxygen,	1.0	18.5	15.62
				100.00

Deutox.	Cobalt,	5.4	100	73
	Oxygen,	2.0	37	27
				100

The precipitated oxide of cobalt, washed and gently heated in contact with air, passes into the state of black peroxide.

When cobalt is heated in chlorine, it takes fire, and forms the chloride. The iodide, phosphuret, and sulphuret of this metal, have not been much examined.

The salts of cobalt are interesting from the remarkable changes of colour which they can exhibit.

Their solution is red in the neutral state, but green with a slight excess of acid; the alkalis occasion a blue-coloured precipitate from the salts of pure cobalt, but reddish-brown when arsenic acid is present; sulphuretted hydrogen produces no precipitate, but hydrosulphurets throw down a black powder, soluble in excess of the precipitant; tincture of galls gives a yellowish-white precipitate; oxalic acid throws down the red oxalate. Zinc does not precipitate this metal.

The sulphate is formed by boiling sulphuric acid on the metal, or by dissolving the oxide in the acid. By evaporation, the salt may be obtained in acicular rhomboidal prisms of a reddish colour. These are insoluble in alcohol, but soluble in 24 parts of water. It consists, by the analysis of Bucholz, of—

	Expert.				*Theory.*
Acid,	26	or 1 prime	5.0		24.4
Protoxide,	30	1 do.	6.4		31.4
Water,	44	8 do.	9.		44.2
	100		20.4		

See SALT.

The nitrate forms prismatic red deliquescent crystals. It is decomposable by gentle ignition. The muriate is easily formed by dissolving the oxide in muriatic acid. The neutral solution is blue when concentrated, and red when diluted; but a slight excess of acid makes it green. According to Klaproth, a solution of the pure muriate forms a sympathetic ink, whose traces become blue when the paper is heated; but if the salt be contaminated with iron, the traces become green. I find that the addition of a little nitrate of copper to the solution forms a sympathetic ink, which by heat gives a rich greenish-yellow colour. When a small quantity of muriate of soda, of magnesia, or of lime, is added to the ink, its traces disappear very speedily on removal from the fire; showing that the vivid green, blue, or yellow colour, is owing to the concentration of the saline traces by heat, and their disappearance, to the reabsorption of moisture. At a red heat, the greater part of the muriate sublimes in a grey-coloured chloride. The acetate forms a sympathetic ink, whose traces being heated, become of a dull blue colour. The arseniate of cobalt is found native in a fine red efflorescence, and in crystals. See ORES of Cobalt. A cream-tartrate of cobalt may be obtained in large rhomboidal crystals, by adding the tartrate of potash to cobaltic solutions, and slow evaporation. An ammonia-nitrate of cobalt may be formed in red cubical crystals, by adding ammonia in excess to the nitric solution, and evaporating at a very gentle heat. They have an urinous taste, and are permanent in the air. Oxide of cobalt does not appear to be capable of dissolving directly in ammonia, and a combination between the two substances can take place only under the two following circumstances: 1. Either the oxide of cobalt combines with an acid, and in this state forms a double salt with the ammonia, which is also combined with the same acid; as for example, in the carbonate of oxide of cobalt and ammonia; nitrate of oxide of cobalt and ammonia, &c.; or 2d, when the proportion of acid is insufficient to saturate both the oxide of cobalt and the ammonia. If the above ammoniacal liquid, previously saturated with oxygen, be committed to a rapid spontaneous evaporation, it yields a compound of *ammonia* with *nitric and cobaltic acids*, in brown-coloured, apparently four-sided prisms, with square bases. *Leopold Gmelin. Annals of Phil.* N. S. ix. 69.

The red oxalate is soluble in an excess of oxalic acid, and hence neutral oxalate of potash is the proper reagent for precipitating cobalt. The phosphate may be formed by double decomposition. It is an insoluble purple powder, which, heated along with eight parts of gelatinous alumina, produces a beautiful blue pigment, a substitute for ultra-marine. The colouring power of oxide of cobalt on vitrifiable mixtures is greater perhaps than that of any other metal. One grain gives a full blue to 240 grains of glass. Zaffre is a mixture of flint powder and an impure oxide of cobalt, prepared by calcination of the ores. Smalt and azure blue are merely cobaltic glass in fine powder. See GLASS.

COBALUS. The demon of mines, which obstructed and destroyed the miners. The church service of Germany formerly contained a form of prayer for the expulsion of the fiend. The ores of the preceding metal being at first mysterious and intractable, were nicknamed cobalt.

COCCOLITE. A mineral of a green colour of various shades, which occurs massive; in loosely aggregated concretions; and crystallized in six-sided prisms, with two opposite acute lateral edges, and bevelled on the extremities, with the bevelled plains set on the acute lateral edges; or in four-sided prisms. The crystals are generally rounded on the angles and edges. The internal lustre is vitreous. Cleavage, double oblique angular. Fracture uneven. Translucent on the edges. It scratches apatite, but not felspar. Is brittle. Sp. gr. 3.3. It fuses with difficulty before the blowpipe. Its constituents are silica 50, lime 24, magnesia 10, alumina 1.5, oxide of iron 7, oxide of manganese 3, loss 4.5. *Vauquelin.*

It occurs along with granular limestone, garnet, and magnetic ironstone, in beds subordinate to the trap formation. It is found at Arendal in Norway, Nericke in Sweden, Barkas in Finland, the Hartz, Lower Saxony, and Spain.

COCCULUS INDICUS. The fruit of the *menispermum cocculus*, a shrub which grows in sand amid rocks on the coasts of Malabar, and other parts of the East Indies. The fruit is blackish, and of the size of a large pea. It contains, 1*st*, about one-half of its weight of a concrete fixed oil; 2*d*, an albuminous vegeto-animal substance; 3*d*, a peculiar colouring matter; 4*th*, one-fiftieth of *picrotoxia*; 5*th*, one-half its weight of fibrous matter; 6*th*, bimalate of lime and potash; 7*th*, sulphate of potash; 8*th*, muriate of potash; 9*th*, phosphate of lime; 10*th*, a little iron and silica. It is poisonous; and is frequently employed to intoxicate or poison fishes. The deleterious ingredient is the PICROTOXIA, which see.

COCHINEAL was at first supposed to be a grain, which name it still retains by way of eminence among dyers, but naturalists soon discovered that it was an insect. It is brought to us from Mexico, where the insect lives upon different species of the opuntia.

Fine cochineal, which has been well dried and properly kept, ought to be of a grey colour inclining to purple. The grey is owing to a powder which covers it naturally, a part of which it still retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed. Cochineal will keep a long time in a dry place. Hellot says, that he tried some one hundred and thirty years old, and found it produce the same effect as new.

MM. Pelletier and Caventou have lately found that the very remarkable colouring matter which composes the principal part of cochineal, is mixed with a peculiar animal matter, a fat like common fat, and with different salts. The fat having been separated by ether, and the residuum treated with boiling alcohol, they allowed the alcohol to cool as they gently evaporated it, and by this means they obtained the colouring matter; but still mixed with a little fat and animal matter. These were separated from it by again dissolving it in cold alcohol, which left the animal matter untouched, and by mixing the solution with ether; and thus precipitating the colouring matter in a state of great purity, which they have called *carminium*. It melts at 122° Fahr. becomes puffy, and is decomposed, but does not yield ammonia. It is very soluble in water, slightly in alcohol, and not at all in ether, unless by the intermediation of fat. Acids change it from crimson, first to bright red, and then to yellow; alkalis, and, generally speaking, all protoxides turn it violet; alumina takes it from water. Lake is composed of carminium and alumina. Carmine is a triple compound of an animal matter, *carminium*, and an acid which enlivens the colour. The action of muriatic acid in changing the crimson colour of cochineal into a fine scarlet, is similar.

Dr. John calls the red colouring matter cochenilin. He says, the insect consists of,

Cochenilin,	50.0
Jelly,	10.5
Waxy fat,	10.0
Gelatinous mucus,	14.0
Shining matter,	14.0
Salts,	1.5
	100.0

COFFEE. The seeds of the *coffea arabica* are contained in an oval kernel, enclosed in a pulpy berry, somewhat like a cherry. The ripe fruit is allowed slightly to ferment, by which the pulp is more easily detached from the seeds. These are afterwards washed, carefully dried in the sun, and freed from adhering membranes by winnowing. Besides the peculiar bitter principle, which we have described under the name *Cafein*, coffee contains several other vegetable products. According to Cadet, 64 parts of raw coffee consist of 8 gum, 1 resin, 1 extractive and bitter principle, 3.5 gallic acid, 0.14 albumen, 43.5 fibrous insoluble matter, and 6.86 loss. Hermann found in 1920 grains of

	Levant Coffee.	Mart. Coffee.
Resin,	74	68
Extractive,	320	310
Gum,	130	144
Fibrous matter,	1335	1386
Loss,	61	12
	1920	1920

The nature of the volatile fragrant principle developed in coffee by roasting, has not been ascertained. The Dutch in Surinam improve the flavour of their coffee by suspending bags of it, for two years, in a dry atmosphere. They never use new coffee.

Coffee is diuretic, sedative, and a corrector of opium. It should be given as medicine in a strong infusion, and is best cold. In spasmodic asthma it has been particularly serviceable; and it has been recommended in gangrene of the extremities arising from hard drinking.

See Cafein.

COHESION, or attraction of cohesion, is that power by which the particles of bodies are held together. The absolute cohesion of solids is measured by the force necessary to pull them asunder. Heat is excited at the same time At the iron cable manufactory of Captain Brown, a cylindrical bar of iron, 1½ inch diameter, was drawn asunder by a force of 43 tons. Before the rupture, the bar lengthened about five inches, and the section of fracture was reduced nearly three-eighths of an inch. About this part a degree of heat was generated, which, according to Mr. Barlow of Woolwich, rendered it unpleasant, if not in a slight degree painful, to grasp the bar in the hand. The same thing is shown in a greater degree in wire-drawing. When the force is applied to compress the body, it becomes shorter in the direction of the force, which is called the *compression;* and the area of its section at right angles to the force, expands. The cohesion, calculated from the transverse strength, is as near, or perhaps nearer, the real cohesion, than that obtained by pulling the body asunder. The cohesive force of metals is much increased by wire-drawing, rolling, and hammering them. In the elaborate tables of cohesion drawn up by Mr. Thomas Tredgold, and published in the 50th vol. of Tilloch's Magazine, the specific cohesion of plate glass (a pretty uniform body) is denoted by unity.

The following table is the result of experiments by George Rennie, jun. Esq. published in the first part of the Phil. Transactions for 1818.

Mr. Rennie found a cubical inch of the following bodies crushed by the following weights:—

	lbs. av.
Elm, ...	1284
American pine, ...	1606
White deal, ...	1928
English oak, ...	3860
Ditto of five inches long, slipped with,	2572
Ditto, of four inches, ditto, .	5147
A prism of Portland stone, two inches long, ...	805
Ditto statuary marble, . .	3216
Craigleith stone, . . .	8688

Cubes of 1½ inch.

	Sp. gr.	
Chalk, . . .	—	1127
Brick of a pale red colour,	2.085	1265
Roe-stone, Gloucestershire,	—	1449
Red brick, mean of two trials,	2.168	1817
Yellow face baked Hammersmith paviors, three times,	—	2254
Burnt ditto, mean of two trials,	—	3243
Stourbridge, or fine brick,	—	3864
Derby grit, a red friable sandstone, ...	2.316	7070
Derby grit from another quarry,	2.428	9776
Killaly white freestone, not stratified, . . .	2.423	10264
Portland, . . .	2.428	10284
Craigleith, white freestone,	2.452	12346
Yorkshire paving, with the strata,	2.507	12856
Ditto, against the strata,	2.507	12856
White statuary marble, not veined, . . .	1.760	23632
Bramley-Fall sandstone, near Leeds, with strata, .	2.506	13632
Ditto, against strata, .	2.506	13632
Cornish granite, . .	2.662	14302
Dundee sandstone, or breccia, two kinds, . .	2.530	14918
A two inch cube of Portland,	2.423	14918
Craiglieth, with strata, .	2.452	15560
Devonshire red marble, variegated, . . .	—	16712
Compact limestone, .	2.584	17354
Peterhead granite, hard close-grained, . . .	—	18636
Black compact limestone, Limerick, . . .	2.598	19924
Purbeck, . . .	2.599	20610
Black Brabant marble, .	2.697	20742
Very hard freestone, .	2.528	21254
White Italian veined marble,	2.726	21783
Aberdeen granite, blue kind,	2.625	24556

Cubes of different metals of ¼th inch were crushed by the following weights:

	lbs.av.
Cast iron,	9773
Cast copper,	7318
Fine yellow brass,	10304
Wrought copper,	6440
Cast tin,	966
Cast lead,	483

Bars of different metals, six inches long, and a quarter of an inch square, were suspended by nippers, and broken by the following weights:

Cast iron, horizontal,	1166
Ditto, vertical,	1218
Cast steel, previously tilted,	8391
Blistered steel, reduced by the hammer,	8322
Shear steel ditto,	7977
Swedish iron ditto,	4504
English iron ditto,	3492
Hard gun metal, mean of two trials,	2273
Wrought copper, reduced by hammer,	2112
Cast copper,	1192
Fine yellow brass,	1123

	lbs.av.
Cast tin,	296
Cast lead,	114

For the experiments on the twist of bars we must refer to the paper.

The strengths of Swedish and English iron do not bear the same proportion to each other in these experiments, that they do when we compare the trials of Count Sickingen with those made at Woolwich, of which an account was given in the *Annals of Philosophy*, vii. 320. From that comparison, the proportional strengths were as follows:

English iron,	348·38
Swedish iron,	549·25

But from Mr. Rennie's experiments, the proportional strengths are:

English iron,	348·38
Swedish iron,	449·34

A very material difference, which ought to be attended to.

The following Table contains a view of some former experiments, on the cohesive strengths or tenacities of bodies.

A wire one-tenth inch of	zinc breaks with	26 pounds.	Mechenbroek.
Do.	lead	29¼	Emerson.
Do.	tin	49¼	do.
Do.	copper	299¼	do.
Do.	brass	360	do.
Do.	silver	370	do.
Do.	iron	450	do.
Do.	gold	500	do.
A cylinder 1 inch	iron	63320	Rumford.

According to Sickingen, the relative cohesive strengths of the metals are as follows:

Gold,	150955
Silver,	190771
Platina,	262361
Copper,	304696
Soft iron,	362927
Hard iron,	559880

A wire of iron 0·078 or $\frac{1}{12.8}$ of an inch, will just support 549·25 pounds. Emerson's number for gold is excessively incorrect. In general, iron is about 4 times stronger than oak, and 6 times stronger than deal.

COHOBATION. The continuous redistillation of the same liquid from the same materials.

COLCHICUM AUTUMNALE. A medicinal plant, the vinous infusion of whose root has been shewn by Sir E. Home to possess specific powers of alleviating gout, similar to those of the empirical preparation called *Eau Medicinale D'Husson*. The sediment of the infusion ought to be removed by filtration, as it occasions gripes, sickness, and vomiting.

COLCOTHAR. The brown-red oxide of iron, which remains after the distillation of the acid from sulphate of iron: it is used for polishing glass and other substances by artists, who call it crocus, or crocus martis.

COLD. The privation of heat. See CALORIC, CONGELATION, and TEMPERATURE.

COLOCYNTHINE. Colocynth treated with alcohol yields the bitter substance much purer than when water is used. The alcoholic solution evaporated, yields a very brittle substance, of a gold yellow colour; which when put into cold water produces a solution, while white opaque filaments remain, which ultimately form a soft semi-transparent yellow mass resembling some resins.

This substance, containing the bitterness of the colocynth, appears to be a peculiar principle. It is very soluble in alcohol, far less so in water, but affords with it, a solution of extreme bitterness and frothing on agitation. *Vauquelin, Journ. de Pharmacie* for 1824, 416.

COLOPHONITE. A mineral of a blackish or yellowish-brown, or orange-red colour; of a resino-adamantine lustre; and conchoidal fracture. Its sp. gr. is 4.0. It consists of silica 35, alumina 13.5, lime 29.0, magnesia 6.5, oxide of iron 7.5, oxide of manganese 4.75, and oxide of titanium 0.5. It occurs massive, in angulo-granular concretions, and in rhomboidal dodecahedrons, whose surfaces have a melted appearance. It is the resinous garnet of Haüy and Jameson. It is found in magnetic ironstone at Arendal in Norway. It occurs also in Piedmont and Ceylon.

COLOPHONY. Colophony, or black resin, is the resinous residuum after the distillation of the light oil, and thick dark reddish balsam, from turpentine.

COLOURING MATTER. See Dyeing.

COLUMBITE. A mineral found at Haddam in Connecticut. It occurs in small amorphous masses, and in minute crystals, disseminated in a granitic aggregate. Colour greyish-black; opaque; fracture imperfectly conchoidal. Scratches glass, but does not strike fire with steel. Powder dark brown: sp. gr. 5·9. Borax dissolves it very slowly at the blowpipe into a pale yellowish glass. The form of the crystal is a compressed rectangular prism, truncated on the lateral edges; or a four-sided pyramid. The columbite is an ore of the Tantalum of Berzelius, or Columbium of Hatchett. See *Ores of Tantalum*.

COLUMBIUM. If the oxide of columbium, described under Acid (Columbic), be mixed with charcoal, and exposed to a violent heat in a charcoal crucible, the metal columbium will be obtained. It has a dark grey colour; and when newly abraded, the lustre nearly of iron. Its sp. gr. when in agglutinated particles, was found by Dr. Wollaston to be 5.61. These metallic grains scratch glass, and are easily pulverized. Neither nitric, muriatic, nor nitro-muriatic acid, produces any change in this metal, though digested on it for several days. It has been alloyed with iron and tungsten. See Acid (Columbic).

COMBINATION; the intimate union of the particles of different substances by chemical attraction, so as to form a compound possessed of new and peculiar properties. See Attraction, Equivalent, and Gas.

COMBUSTIBLE. A body which, in its rapid union with others, causes a disengagement of heat and light. To determine this rapidity of combination, or intensity of chemical action, a certain elevation of temperature is necessary, which differs for every different combustible. This difference thrown into a tabular form would constitute their scale of *ascendibility*, or degree of accension.

Stahl adapted, and refined on the vulgar belief of the heat and light coming from the combustible itself; Lavoisier advanced the opposite and more limited doctrine, that the heat and light proceeded from the oxygenous gas in air and other bodies, which he regarded as the true *pabulum* of fire. Stahl's opinion is perhaps more just than Lavoisier's; for many combustibles burn together, without the presence of oxygen, or of any analogous fancied supporters; as chlorine, and the adjuncts to oxygen, have been unphilosophically called. Sulphur, hydrogen, carbon, and azote, are as much entitled to be styled *supporters*, as oxygen and chlorine, for potassium burns vividly in sulphuretted hydrogen, and in prussine, and most of the metals burn with sulphur alone. Heat and light are disengaged, with a change of properties, and reciprocal saturation of the combining bodies. All the combustible gases are certainly capable of affording heat, to the degree of incandescence, as is shown by their mechanical condensation.

Sound logic would justify us in regarding oxygen, chlorine, and iodine, as in reality combustible bodies, perhaps more so than those substances vulgarly called combustible. Experiments with the condensing syringe, and the phenomena of the decomposition of *euchlorine*, prove that light as well as heat may be afforded by oxygen and chlorine. If the body, therefore, which emits, or can emit, light and heat in copious streams, by its action on others, be a combustible, then chlorine and oxygen merit that designation as much as charcoal and sulphur. Azote is declared by the expounders of the Lavoisierian creed to be a simple *incombustible*. Yet its mechanical condensation proves that it can afford, from its own resources, an incandescent heat; and with chlorine, iodine, and metallic oxides—all incombustibles on the antiphlogistic notion, it forms compounds possessed of combustible properties, in a pre-eminent and a tremendous degree of concentration. It is melancholy to reflect with what easy credulity the fictions of the Lavoisierian faith have been received and propagated by chemical compilers, sometimes sufficiently incredulous on subjects of rational belief. *See the next Article.*

The electric polarities unquestionably show, what no person can wish to deny, that between oxygen, chlorine, iodine, on one hand, and hydrogen, charcoal, sulphur, phosphorus, and the metals, on the other, there exist striking differences. The former are attracted by the positive pole, the latter by the negative, in voltaic arrangements. But still nothing definitive can be inferred from this fact; because in the actions of what are called combustibles on each other, without the presence of the other class, we have an exhibition of opposite electrical polarities. Sulphur and metallic plates, by mutual friction or mere contact, produce electrical changes, which apparently prove that sulphur should be ranked along with oxygen, chlorine, and acids, apart from combustibles, whose polarities are negative. Sulphuretted hydrogen, in its electrical relations to metals, ranks also with oxygen and acids. How vague and fallacious a rule of classification electrical polarity would afford, may be judged of from the following unquestionable facts: "Among the substances that combine chemically, all those, the electrical energies of which are well known, exhibit opposite states; thus copper and zinc, gold and quicksilver, sulphur and the metals, the acid and alkaline substances, afford apposite instances. In the voltaic combination of diluted nitrous acid, zinc and copper, as is well known, the side of the zinc exposed to the acid is positive. But in combinations of zinc, water, and diluted nitric acid, the surface exposed to the acid is negative; though if the chemical action of the acid on the zinc had been the cause of the effect, it ought to be the same in both cases." *On some Chemical Agencies of Electricity, by Sir H. Davy. Phil. Trans.* 1807.

Combustibles have been arranged into simple and compound. The former consist of hydrogen, carbon, boron, sulphur, phosphorus, and nitrogen, besides all the metals. The latter class comprehends the hydrurets, carburets, sulphurets, phosphorets, metallic alloys, and organic products.

When the pure oxides of iron, cobalt, or nickel are reduced by hydrogen gas, at temperatures but very little above that of boiling mercury, metals are obtained, which, when allowed to cool in the hydrogen gas, inflame spontaneously by exposure to the atmosphere. If the reduction has been effected at a red heat, this does not take place.

When the same oxides are mixed with a little alumina, the metals obtained, as before, inflame spontaneously in the atmosphere, even though the heat used has been that of redness, and yet from the quantity of oxygen disengaged, it has been evident that the alumine has not been de-oxidized.

When a metal thus competent to inflame in the air is heated in carbonic acid gas, it loses its peculiar property, but resumes it on being heated once more in hydrogen gas, and allowed to cool as before.

The hydrogen, however, is not the cause of this inflammation; for when oxalate of iron is heated in a vessel with a narrow neck, so that the acid may be decomposed, and the whole allowed to cool, the metallic iron-powder obtained inflames spontaneously in the atmosphere. No other metal but the three mentioned have presented this phenomenon.

With these effects may possibly be ranged that observed by Dr. Gobel, as produced by the residuum left after igniting the tartrate of lead in close vessels. *Annales des Mines*, xii. 210.

COMBUSTION. The disengagement of heat and light which accompanies chemical combination. It is frequently made to be synonymous with inflammation, a term which might be restricted, however, to that peculiar species of combustion in which gaseous matter is burned. Ignition is the incandescence of a body, produced by extrinsic means, without change of its chemical constitution.

Becher and Stahl, feeling daily the necessity of fire to human existence, and astonished with the *metamorphoses* which this power seemed to cause charcoal, sulphur, and metals to undergo, came to regard combustion as the single phenomenon of chemistry. Under this impression Stahl framed his chemical system, the *Theoria Chemiæ Dogmaticæ*, a title characteristic of the spirit with which it was inculcated by chemical professors, as the infallible code of their science for almost a century. When the discoveries of Scheele, Cavendish, and Priestley, had fully demonstrated the essential part which air played in many instances of combustion, the French school made a small modification of the German hypothesis. Instead of supposing, with Stahl, that the heat and light were occasioned by the *emission* of a *common* inflammable principle from the combustible itself, Lavoisier and his associates dexterously availed themselves of Black's hypothesis of latent heat, and maintained, that the heat and light emanated from the oxygenous air, at the moment of its union or fixation with the inflammable basis. How thoroughly the chemical mind has been perverted by these conjectural notions, our systems of chemistry abundantly prove.

Dr. Robison, in his preface to Black's Lectures, after tracing, with perhaps superfluous zeal, the expanded ideas of Lavoisier to the neglected germs of Hooke and Mayhow, says, "This doctrine concerning combustion, the great, the characteristic phenomenon of chemical nature, has at last received almost universal adoption, though not till after considerable hesitation and opposition; and it has made a complete revolution in chemical science." The French theory of chemistry, as it was called, or hypothesis of combustion, as it should have been named, was for some time classed in certainty with the theory of gravitation. It is vanishing with the phantoms of the day; but the sound logic, the pure candour, the numerical precision of inference, which characterize Lavoisier's Elements, will cause his name to be held in lasting admiration.

It was the rival logic of Sir H. Davy, aided by his unrivalled felicity of investigation, which first recalled chemistry from the labyrinths of fancy, to the more arduous but far more profitable career of reason. His researches on combustion and flame, already rich in blessings to mankind, would alone place him in the first rank of scientific genius. I shall give a somewhat copious account of them, since by some fatality it has happened, that in our most extensive system, where so many pages are devoted to the reveries of ancient chemists, the splendid and useful truths made known by the great chemist of England have been almost overlooked.

Whenever the chemical forces which determine either composition or decomposition are energetically exercised, the phenomena of combustion, or incandescence, with a change of properties, are displayed. The distinction, therefore, between supporters of combustion and combustibles, on which some late systems are arranged, is frivolous and partial. In fact, one substance frequently acts in both capacities, being a supporter *apparently* at one time, and a *combustible* at another. But in both cases the heat and light depend on the same cause, and merely indicate the energy and rapidity with which reciprocal attractions are exerted.

Thus, sulphuretted hydrogen is a combustible with oxygen and chlorine; a supporter with potassium. Sulphur, with chlorine and oxygen, has been called a combustible basis; with metals it acts the part of a supporter; for incandescence and reciprocal saturation result. In like manner, potassium unites so powerfully with arsenic and tellurium as to produce the phenomena of combustion. Nor can we ascribe the appearances to extrusion of latent heat in consequence of condensation of volume. The protoxide of chlorine, a body destitute of any combustible constituent, at the instant of decomposition evolves light and heat with explosive violence; and its volume becomes one-fifth greater. Chloride and iodide of azote, compounds alike destitute of any inflammable matter, according to the ordinary creed, are resolved into their respective elements with tremendous force of inflammation; and the first expands into more than 600 times its bulk. Now, by the prevailing hypothesis of latent caloric, instead of heat and light, a prodigious *cold* ought to accompany such an expansion. The chlorates and nitrates, in like manner, treated with charcoal, sulphur, phosphorus, or metals, deflagrate or detonate while the volume of the combining substances is greatly enlarged. The same thing may be said of the nitroguret of gold and silver. In truth, the combustion of gunpowder, a phenomenon too familiar to mankind, should have been a bar to the reception of Lavoisier's hypothesis of combustion. The subterfuges which have been adopted in order to reconcile them do not merit a detail.

From the preceding facts, it is evident, 1st, That combustion is not necessarily dependent on the agency of oxygen; 2d, That the evolution of the heat is not to be ascribed simply to a gas parting with its latent store of that ethereal fluid, on its fixation or combustion; and, 3dly, "That no peculiar substance or form of matter is necessary for producing the effect, but that it is a *general* result of the actions of any substances possessed of strong chemical attractions, or different electrical relations, and that it takes place in all cases in which an intense and violent motion can be conceived to be communicated to the corpuscles of bodies."

All chemical phenomena indeed may be justly ascribed to motions among the ultimate particles of matter, tending to change the constitution of the mass.

It was fashionable for a while to attribute the caloric evolved in combustion, to a diminished capacity for heat of the resulting substance. Some phenomena, inaccurately observed, gave rise to this generalization. On this subject I shall content myself with stating the conclusions to which MM. Dulong and Petit have come, in consequence of their own recent researches on the laws of heat, and those of Berard and Delaroche. "We may likewise," say these able chemists, "deduce from our researches another very important consequence for the general theory of chemical action, that the quantity of heat developed at the instant of the combination of bodies has no relation to the capacity of the elements; and that, in the greatest number of cases, this loss of heat is not followed by any diminution in the capacity of the compounds formed. Thus, for example, the combination of oxygen and hydrogen, or of sulphur and lead, which produces so great a quantity of heat, occasions no greater alteration in the capacity of water, or of sulphuret of lead, than the combination of oxygen with copper, lead, silver, or of sulphur with carbon, produces in the capacities of the oxides of these metals, or of carburet of sulphur."—"We conceive, that the relations which we have pointed out between the specific heats of simple bodies, and of those of their compounds, prevent the possibility of supposing, that the heat developed in chemical actions owes its origin merely to the heat produced by change of state, or to that supposed to be combined with the material molecules." *Annales de Chimie et Physique*, x.

Mr. Dalton, in treating of the constitution of elastic fluids, lays it down as an axiom, that diminution of volume is the criterion of chemical affinity being exercised; and hence maintains, that the atmospheric air is a mere mixture. Thus, also, the extrication of heat from chemical union has been usually referred to the condensation of volume. The following examples will show the fallacy of such hypotheses. 1. Chlorine and hydrogen mixed, explode by the sunbeam, electric spark, or inflamed taper, with the disengagement of much heat and light; and the volume of the mixture, which is greatly *enlarged* at the instant of combination, suffers no condensation afterwards. Muriatic acid gas, having the mean density of its components, is produced. 2. When one volume of olefiant gas and one of oxygen are detonated together, three and a half gaseous volumes result, the greater part of the hydrogen remains untouched, and a volume and a half of carbonic oxide is formed, with about 1-10th of carbonic acid. 3. The following experiments of M. Gay Lussac on liquid combinations are to the same purpose. 1. A saturated solution of nitrate of ammonia, at the temperature of 61°, and of the density 1.302, was mixed with water in the proportion of 44.05 to 33.76. The temperature of the mixture sank 8.9°; but the density at 61° was 1.159, while the mean density was only 1.151. 2. On adding water to the preceding mixture, in the proportion of 33.64 to 39.28, the temperature sank 3.4°, while the density continued 0.003 above the mean. Other saline solutions presented the same result, though none to so great a degree.

That the internal motions which accompany the change in the *mode* of combination, independent of change of *form*, occasion the evolution of heat and light, is evident from the following observations of Berzelius:—In the year 1811, when he was occupied with examining the combinations of antimony, he discovered, accidentally, that several metalline antimoniates, when they begin to grow red-hot, exhibit a sudden appearance of fire, and then the temperature again sinks to that of the surrounding combustibles. He made numerous experiments to elucidate the nature of this appearance, and ascertained that the weight of the salt was not altered, and that the appearance took place without the presence of oxygen. Before the appearance of fire, these salts are very easily decomposed, but afterwards they are attacked neither by acids nor alkaline leys—a proof that their constituents are now held together by a stronger affinity, or that they are more intimately combined. Since that time he has observed these appearances in many other bodies, as, for example, in green oxide of chromium, the oxides of tantalum and rhodium. (See CHROMIUM).

Mr. Edmund Davy found, that when a neutral solution of platinum was precipitated by hydrosulphuret of potash, and the precipitate dried in air deprived of oxygen, a black compound was obtained, which when heated out of the contact of air, gave out sulphur, and some sulphuretted hydrogen gas, while a combustion similar to that in the formation of the metallic sulphurets appeared, and common sulphuret of platinum remained behind. When we heat the oxide of rhodium, obtained from the soda-muriate, water first comes over; and on increasing the temperature, combustion takes place, oxygen gas is suddenly disengaged, and a suboxide of rhodium remains behind. The two last cases are analogous to that of the protoxide of chlorine, the *euchlorine* of Sir H. Davy. Gadolinite, the silicate of yttria, was first observed by Dr. Wollaston to display a similar lively incandescence. The variety of this mineral with a glassy fracture, answers better than the splintery variety. It is to be heated before the blowpipe, so that the whole piece becomes equally hot. At a red heat it catches fire. The colour becomes greenish-grey, and the solubility in acids is destroyed. Two small pieces of gadolinite, one of which had been heated to redness, were put in aqua regia; the first was dissolved in a few hours; the second was not attacked in two months. Finally, Sir H. Davy observed a similar phenomenon on heating hydrate of zirconia.

The *verbal* hypothesis of thermoxygen by Brugnatelli, with Dr. Thomson's supporters, partial supporters, and semicombustion, need not detain us a moment from the substantial facts, the noble truths, first revealed by Sir H. Davy, concerning the mysterious process of combustion. Of the researches which brought them to light it has been said, without any hyperbole, that "if Bacon were to revisit the earth, this is exactly such a case as we should choose to place before him, in order to give him, in a small compass, an idea of the advancement which philosophy has made since the time when he had pointed out to her the route which she ought to pursue."

The coal mines of England, alike essential to the comfort of her population and her financial resources, had become infested with fire-damp, or inflammable air, to such a degree as to render the mutilation and destruction of the miners, by frequent and tremendous explosions, subjects of sympathy and dismay to the whole nation. By a late explosion in one of the Newcastle collieries, no less than one hundred and one persons perished in an instant; and the misery heaped on their forlorn families, consisting of more than three hundred persons, is inconceivable. To subdue this gigantic power was the task which Sir H. Davy assigned to himself; and which, had his genius been baffled, the kingdom could scarcely hope to see achieved by another. But the stubborn forces of nature can only be conquered, as Lord Bacon justly pointed out, by examining them in the nascent state, and subjecting them to experimental interrogation, under every diversity of circumstance and form. It was this investigation which first laid open the hitherto unseen and inaccessible sanctuary of *Fire*.

As some attempts, however, have been made, to insinuate that Sir H. Davy stole the germ of his discoveries from the late Mr. Tennant, it may be proper to preface the account of them by the following extract from "Resolutions of a Meeting held for considering the Facts relating to the Discovery of the Lamp of Safety."

"*Soho Square*, *Nov.* 20. 1817.

"3d.—That Sir H. Davy not only discovered, independently of all others, and without any knowledge of the unpublished experiments of the late Mr. Tennant on Flame, the principle of the non-communication of explosions through small apertures, but that he has also the sole merit of having first applied it to the very important purpose of a safety-lamp, which has evidently been imitated in the latest lamps of Mr. George Stephenson.

(Signed) Joseph Banks, P. R. S.
William J. Brande.
Charles Hatchett.
William Hyde Wollaston.
Thomas Young."

See the whole document in Tilloch's Magazine, vol. 50. p. 387.

The phenomena of combustion may be conveniently considered under six heads: *1st*, The temperature necessary to inflame different bodies. *2d*, The nature of flame, and the relation between the light and heat which compose it. *3d*, The heat disengaged by different combustibles in burning. *4th*, The causes which modify and extinguish combustion, and of the safe-lamp. *5th*, Invisible combustion. *6th*, Practical inferences.

1*st*, *Of the temperature necessary to inflame different bodies.* 1*st*, A simple experiment shows the successive combustibilities of the different bodies. Into a long bottle with a narrow neck, introduce a lighted taper, and let it burn till it is extinguished. Carefully stop the bottle, and introduce another lighted taper. It will be extinguished before it reaches the bottom of the neck. Then introduce a small tube, containing zinc and dilute sulphuric acid at the aperture of which the hydrogen is inflamed. The hydrogen will be found to burn in whatever part of the bottle the tube is placed. After the hydrogen is extinguished, introduce lighted sulphur. This will burn for some time; and after its extinction phosphorus will be as luminous as in the air, and, if heated in the bottle, will produce a pale yellow flame of considerable density.

Phosphorus is said to take fire when heated to 150° and sulphur to 550°. Hydrogen inflames with chlorine at a lower temperature than with oxygen. By exposing oxygen and hydrogen, confined in glass tubes, to a very dull red (about 800 F.) they explode. When the heat was about 700 F. they combined rapidly with a species of silent combustion. A mixture of common air and hydrogen was introduced into a small copper tube, having a stopper not quite tight; the copper tube was placed in a charcoal fire; before it became visibly red-hot an explosion took place, and the stopper was driven out. We see, therefore, that the inflaming temperature is independent of compression or rarefaction.

The ratio of the combustibility of the different gaseous matters is likewise, to a certain extent, as the masses of heated matters required to inflame them. Thus, an iron wire 1-40th of an inch, heated cherry-red, will not inflame olefiant gas, but it will inflame hydrogen gas. A wire of 1-8th, heated to the same degree, will inflame olefiant gas. But a wire $\frac{1}{200}$ of an inch must be heated to whiteness to inflame hydrogen, though at a low red heat it will inflame biphosphuretted gas. Yet wire of 1-40th, heated even to whiteness, will not inflame mixtures of fire-damp. Carbonic oxide inflames in the atmosphere when brought into contact with an iron wire heated to dull redness; whereas carburetted hydrogen is not inflammable, unless the iron is heated to whiteness, so as to burn with sparks.

These circumstances will explain why a mesh of wire, so much finer or smaller, is required to prevent the explosion from hydrogen and oxygen from passing; and why so coarse a texture and wire are sufficient to prevent the explosion of the fire-damp, fortunately the least combustible of all the inflammable gases known. The flame of sulphur, which kindles at so low a temperature, will exist under refrigerating processes, which extinguish the flame of hydrogen and all carburetted gases.

Let the smallest possible flame be made by a single thread of cotton immersed in oil, and burning immediately upon the surface of the oil. It will be found to yield a flame about 1-30th of an inch in diameter. Let a fine iron wire of $\frac{1}{180}$ of an inch, made into a ring of 1-40th of an inch diameter, be brought over the flame. Though at such a distance, it will instantly extinguish the flame, if it be *cold*: but if it be held above the flame, so as to be slightly heated, the flame may be passed through it without being extinguished. That the effect depends entirely on the power of the metal to abstract the heat of flame is shown by bringing a glass capillary ring of the *same* diameter and size over the flame. This being a much worse conductor of heat, will not, even when cold, extinguish it. If its size, however, be made greater, and its circumference smaller, it will act like the metallic wire, and require to be heated to prevent it from extinguishing the flame. Now a flame of sulphur may be made much smaller than that of hydrogen; one of hydrogen may be made much smaller than that of a wick fed with oil; and that of a wick fed with oil smaller than that of carburetted hydrogen. A ring of cool wire, which instantly extinguishes the flame of carburetted hydrogen, diminishes but slightly the size of a flame of sulphur of the same dimensions.

By the following simple contrivance, we may determine the relative facility of burning, among different combustibles. Prepare a series of metallic globules of different sizes, by fusion at the end of iron wires, and light a series of very minute flames of different bodies all of one size. If a globule 1-20th of an inch diameter be brought near an oil flame of 1-30th in diameter, it will extinguish it, when cold, at the distance of a diameter. The size of the spherule adequate to the extinction of the particular flame will be a measure of its combustibility. If the globule be heated, however, the distance will diminish at which it produces extinction. At a white heat, the globule, in the above instance, does not extinguish it by actual contact, though at a dull red heat it immediately produces the effect.

2d, *Of the nature of flame, and of the relation between the light and the heat which compose it.* The flame of combustible bodies may, in all cases, be considered as the combustion of an *explosive mixture* of inflammable gas, or vapour, with air. It cannot be regarded as a mere combustion, at the surface of contact, of the inflammable matter. This fact is proved by holding a taper, or a piece of burning phosphorus, within a large flame made by the combustion of alcohol. The flame of the taper, or of the phosphorus, will appear in the centre of the other flame, proving that there is oxygen even in its interior part. When a wire-gauze safe-lamp is made to burn in a very explosive mixture of coal gas and air, the light is feeble, and of a pale colour. Whereas the flame of a current of coal gas burnt in the atmosphere, as is well known by the phenomena of the gas lights, is extremely brilliant. It becomes, therefore, a problem of some interest, "Why the combustion of explosive mixtures, under different circumstances, should produce such different appearances?" In reflecting on the circumstances of these two species of combustion, Sir H. Davy was led to imagine that the cause of the superiority of the light of the *stream* of coal gas, might be owing to the *decomposition* of a part of the gas, towards the interior of the flame, where the air was in the smallest quantity, and the deposition of solid charcoal, which first by its *ignition*, and afterwards by its *combustion*, increased, in a high degree, the intensity of the light. The following experiments shew, that this is the true solution of the problem.

If we hold a piece of wire-gauze, of about 900 apertures to the square inch, over a stream of coal gas issuing from a small pipe, and if we inflame the gas above the wire-gauze left almost in contact with the orifice of the pipe, it burns with its usual bright light. On raising the wire-gauze so as to cause the gas to be mixed with more air before it inflames, the light becomes feebler, and at a certain distance the flame assumes the precise character of that of an explosive mixture burning within the lamp. But though the light is so feeble in this case, the heat is greater than when the light is much more vivid. A piece of wire of platina, held in this feeble blue flame, becomes instantly white-hot.

On reversing the experiment, by inflaming a stream of coal gas, and passing a piece of wire-gauze gradually from the summit of the flame to the orifice of the pipe, the result is still more instructive. Ii is found that the apex of the flame, intercepted by the wire-gauze, affords no solid charcoal; but in passing it downwards, solid charcoal is given off in considerable quantities, and prevented from burning by the cooling agency of the wire-gauze. At the bottom of the flame, where the gas burned blue, in its immediate contact with the atmosphere, charcoal ceased to be deposited in visible quantities.

The principle of the increase of the brilliancy and density of flame, by the production and ignition of solid matter, appears to admit of many applications. Thus, olefiant gas gives the most brilliant white light of all combustible gases, because, as we learn from Berthollet's experiments, related under carburetted hydrogen, at a very high temperature it deposits a very large quantity of solid carbon. Phosphorus, which rises in vapour, at common temperatures, and the vapour of which combines with oxygen at those temperatures, is always luminous; for each particle of acid formed must, there is every reason to believe, be white-hot. So few of these particles, however, exist in a given space, that they scarcely raise the temperature of a solid body exposed to them, though, as in the rapid combustion of phosphorus, where immense numbers are existing in a small space, they produce a most intense heat.

The above principle readily explains the appearances of the different parts of the flames of burning bodies, and of flame urged by the blowpipe. The point of the inner blue flame, where the heat is greatest, is the point where the whole of the charcoal is burned in its gaseous combinations, without previous deposition.

It explains also the intensity of the light of those *flames* in which *fixed* solid matter is produced in combustion, such as the flame of phosphorus and of zinc in oxygen, &c. and of potassium in chlorine, and the feebleness of the light of those flames in which gaseous and volatile matter alone is produced, such as those of hydrogen and of sulphur in oxygen, phosphorus in chlorine, &c.

It offers means of increasing the light of certain burning substances, by placing in their flames even incombustible substances. Thus the intensity of the light of burning sulphur, hydrogen, carbonic oxide, &c. is wonderfully increased by throwing into them oxide of zinc, or by placing in them very fine amianthus or metallic gauze.

It leads to deductions concerning the chemical nature of bodies, and various phenomena of their decomposition. Thus ether burns with a flame which seems to indicate the presence of olefiant gas in that substance. Alcohol burns with a flame similar to that of a mixture of carbonic oxide and hydrogen. Hence the first is probably a binary compound of olefiant gas and water, and the second of carbonic oxide and hydrogen. When protochloride of copper is introduced into the flame of a candle or lamp, it affords a peculiar dense and brilliant red light, tinged with green and blue towards the edges, which seems to depend upon the chlorine being separated from the copper by the hydrogen, and the ignition and combustion of the solid copper and charcoal.

Similar explanations may be given of the phenomena presented by the action of other combinations of chlorine on flame; and it is probable, in many of those cases, when the colour of flame is changed by the introduction of incombustible compounds, that the effect depends on the production, and subsequent ignition or combustion, of inflammable matter from them. Thus the rose-coloured light given to flame by the compounds of strontium and calcium, and the yellow colour given by those of barium, and the green by those of boron, may depend upon a temporary production of these bases, by the inflammable matter of the flam Dr. Clarke's experiments on the reduction of barytes, by the hydroxygen lamp, is favourable to this idea. Nor should any supposed inadequacy of heat in ordinary flame prevent us from adopting this conclusion. Flame, or gaseous matter, heated so highly as to be luminous, possesses a temperature beyond the white heat of solid bodies, as is shown by the circumstance, that air not luminous will communicate this degree of heat. This is proved by a simple experiment. Hold a fine wire of platinum about 1-20th of an inch from the exterior of the middle of the flame of a spirit-lamp, and conceal the flame by an opaque body. The wire will become white-hot in a space where there is no visible light. The real temperature of visible flame is perhaps as high as any we are acquainted with. Mr. Tennant used to illustrate this position, by fusing a small filament of platinum in the flame of a common candle.

These views will probably offer illustrations of electrical light. The voltaic arc of flame from the great battery differs in colour and intensity, according to the substances employed in the circuit, and is infinitely more brilliant and dense with charcoal than with any other substance. May not this depend, says Sir H. Davy, upon particles of the substances separated by the electrical attractions? And the particles of charcoal, being the lightest among solid bodies (as their prime equivalent shows), and the least coherent, would be separated in the largest quantities.

The heat of flames may be actually diminished by increasing their light (at least the heat communicable to other matter), and *vice versa*. The flame from combustion, which produces the most intense heat amongst those which have been examined, is that of a mixture of oxygen and hydrogen compressed in Newmann's blowpipe apparatus. (See BLOWPIPE). This flame is hardly visible in bright day-light, yet it instantly fuses the most refractory bodies; and the light from solid bodies ignited in it is so vivid as to be painful to the eye. This application certainly originated from Sir H. Davy's discovery, that the explosion from oxygen and hydrogen would not communicate through very small apertures, and he himself first tried the experiment with a fine glass capillary tube. The flame was not *visible* at the end of this tube, being overpowered by the brilliant star of the glass, ignited at the aperture.

3. *Of the heat disengaged by different combustibles in the act of burning.*

Lavoisier, Crawford, Dalton, and Rumford, in succession, made experiments to determine the quantity of heat evolved in the combustion of various bodies. The apparatus used by the last was perfectly simple, and perhaps the most precise of the whole. The heat was conducted by flattened pipes of metal, into the heart of a body of water, and was measured by the temperature imparted. The following is a general table of results:—

Substances burned, 1 lb.	Oxygen consumed in lbs.	Ice melted in lbs.			
		Lavoisicr.	Crawford.	Dalton.	Rumford.
Hydrogen, . .	7·5	295·6	480	320	
Carburetted hydrogen,	4			85	
Olefiant gas, . .	3·50			88	
Carbonic oxide, .	0·58			25	
Olive oil, . . .	3·00	149	89	104	94·07
Rape oil, . . .	3·0				124·10
Wax, . . .	3·0	133	97	104	126·24
Tallow, . . .	3·0	96		104	111·58
Oil of turpentine, .				60	
Alcohol, . . .	2·0?			58	67·47
Ether, sulphuric, .	3			62	107·03
Naphtha, . . .					97·83
Phosphorus, . .	1·33	100		60	
Charcoal, . .	2·66	96·5	69	40	
Sulphur, . . .	1·00			20	
Camphor, . .				70	
Caoutchouc, . .				42	

The discrepancies in the preceding table are sufficient to show the necessity of new experiments on the subject. Count Rumford made a series of experiments on the heat given out during the combustion of different woods. He found that one pound of wood by burning, produced as much heat as would have melted from about 34 to 54 pounds of ice. The average quantity is about 40. MM. Clement and Desormes find that woods give out heat in the ratio of their respective quantities of carbon; which they state to be equal to one half of their total weight. Hence, they assign 48 pounds as the quantity of ice melted, in burning one of wood. In treating of acetic acid and carbon, I have already taken occasion to state, that they appear probably to overrate the proportion of carbon in woods.

The preceding table is incorrectly given in several respects by our systematic writers; Dr. Thomson, for example, states that 1 pound of hydrogen consumes only 6 pounds of oxygen, though the saturating proportion assigned by him is 8 pounds. The proportions of oxygen consumed by olive oil, phosphorus, charcoal, and sulphur, are all in like manner erroneous.

In vol. i. p. 184, of Dr. Black's Lectures, we have the following notes. "100 pounds weight of the best Newcastle coal, when applied by the most judiciously constructed furnace, will convert about 1½ wine hogsheads of water, into steam that supports the pressure of the atmosphere." 1½ hogsheads of water weigh about 790 pounds. Hence, 1 part of coal will convert nearly 8 parts of water into steam. Count Rumford says, that the heat generated in the combustion of 1 pound of pit-coal, would make $36\frac{3}{10}$ pounds of ice-cold water boil. But we know that it requires fully 5½ times as much heat to convert the boiling water into steam. Therefore, $\frac{36.3}{5.5} = 6\frac{3}{5}$, is the weight of water that would be converted into steam by one pound of coal.

Mr. Watt found, that it requires 8 feet surface of boiler to be exposed to fire to boil off one cubic foot of water per hour, and that a bushel or 84 pounds of Newcastle coal so applied, will boil off from 8 to 12 cubic feet. He rated the heat expended in boiling off a cubic foot of water, to be about six times as much as would bring it to a boiling heat from the medium temperature (55°) in this climate. The mean quantity is 10 cubic feet, which weigh 625 pounds. Hence, 1 pound of coal burnt, is equivalent to boil off in steam nearly 7½ lbs. of water, at the temperature of 55°.

In situations where wood was employed for fuel to Mr. Watt's engines, he allowed three times the weight of it, that he did of Newcastle coal. The cubical coal of the Glasgow coal district is reckoned to have only ¾ the calorific power of the Newcastle coal; and the small coal or culm requires to be used in double weight, to produce an equal heat with the larger pieces. A bushel of Newcastle coal is equivalent to a hundred weight of the Glasgow.

I shall now describe the experiments recently made on this subject by Sir H. Davy, subservient to his researches on the nature of flame. A mercurial gas-holder, furnished with a system of stop-cocks, terminated in a strong tube of platinum, having a minute aperture. Above this was fixed a copper cup filled with olive oil, in which a thermometer was placed. The oil was heated to 212°, to prevent any difference in the communication of heat, by the condensation of aqueous vapour; the pressure was the same for the different gases; and they were consumed as nearly as possible in the same time, and the flame applied to the same point of the copper cup, the bottom of which was wiped after each experiment. The results were as follows:—

Substances.	Rise of therm. from 212° to	Oxygen consumed.	Ratios of heat.
Olefiant gas,	270°	6.0	9.66
Hydrogen,	238	1.0	26.0
Sulph. hydrogen,	232	3.0	6.66
Coal gas,	236	4.0	6.00
Carbonic oxide,	218	1.0	6.00

The *data* on which Sir H. calculates the ratios of heat are the elevations of temperature and the quantities of oxygen consumed conjointly. We see that hydrogen produces more heat in combustion than any of its compounds, a fact accordant with Mr. Dalton's results in the former table; only Sir H. Davy's ratio is more than double that of Mr. Dalton's, as to hydrogen, and carburetted hydrogen. On this point, however, Sir H. with his usual sagacity remarks, that it will be useless to reason upon the ratios as exact, for charcoal was deposited from both the olefiant gas and coal gas during the experiment, and much sulphur was deposited from the sulphuretted hydrogen. It confirms, however, the general conclusions, and proves that hydrogen stands at the head of the scale, and carbonic oxide at the bottom. It might at first view be imagined, that, according to this scale, the flame of carbonic oxide ought to be extinguished by rarefaction at the same degree as that of carburetted hydrogen; but it must be remembered, as has been already shown, that carbonic oxide is much more easily kindled, a more accendible gas.

4. *Of the causes which modify or extinguish combustion or flame.*

The earlier experimenters upon the Boylean vacuum observed, that flame ceased in highly rarefied air; but the degree of rarefaction necessary for this effect has been differently stated. On this point Sir H. Davy's investigations are peculiarly beautiful and instructive. When hydrogen gas, slowly produced from a proper mixture, was inflamed at a fine orifice of a glass tube, as in Priestley's philosophical candle, so as to make a jet of flame of about 1-6th of an inch in height, and introduced under the receiver of an air-pump, containing from 200 to 300 cubical inches of air, the flame enlarged as the receiver became exhausted; and when the gauge indicated a pressure between 4 and 5 times less than that of the atmosphere, was at its maximum of size; it then gradually diminished below, but burned above, till its pressure was between 7 and 8 times less; when it became extinguished.

To ascertain whether the effect depended upon the deficiency of oxygen, he used a larger jet with the same apparatus, when the flame, to his surprise, burned longer; even when the atmosphere was rarefied 10 times; and this in repeated trials. When the larger jet was used, the point of the glass tube became white-hot, and continued red-hot till the flame was extinguished. It immediately occurred to him, that the heat communicated to the gas by this tube was the cause that the combustion continued longer in the last trials when the larger flame was used; and the following experiments confirmed the conclusion. A piece of wire of platinum was coiled round the top of the tube, so as to reach into and above the flame. The jet of gas of 1-6th of an inch in height was lighted, and the exhaustion made. The wire of platinum soon became white-hot in the centre of the flame, and a small point of wire near the top fused. It continued white-hot till the pressure was 6 times less. When it was 10 times, it continued red-hot at the upper part, and as long as it was dull red, the gas, though certainly extinguished below, continued to burn in contact with the hot wire; and the combustion did not cease until the pressure was reduced 13 times.

It appears from this result, that the flame of hydrogen is extinguished in rarefied atmospheres, only when the heat it produces is insufficient to keep up the combustion; which appears to be when it is incapable of communicating visible ignition to metal; and as this is the temperature required for the inflammation of hydrogen (see section 1st), at common pressure, it appears that its *combustibility* is neither diminished nor increased by rarefaction from the removal of pressure.

According to this view with respect to hydrogen, it should follow, that those amongst other combustible bodies, which require less heat for their accension, ought to burn in more rarefied air than those that require more heat; and those which *produce* much heat in their combustion ought to burn, other circumstances being the same, in more rarefied air, than those that produce little heat. Every experiment since made confirms these conclusions. Thus olefiant gas, which approaches nearly to hydrogen, in the temperature produced by its combustion, and which does not require a much higher temperature for its accension, when its flame was made by a jet of gas from a bladder connected with a small tube, furnished with a wire of platinum, under the same circumstances as hydrogen, ceased to burn when the pressure was diminished between 10 and 11 times. And the flames of alcohol and of the wax taper, which require a greater consumption of caloric for the volatilization and decomposition of their combustible matter, were extinguished when the pressure was 5 or 6 times less without the wire of platinum, and 7 or 8 times less when the wire was kept in the flame. Light carburetted hydrogen, which produces, as we have seen, less heat in combustion than any of the common combustible gases, except carbonic oxide, and which requires a higher temperature for its accension than any other, has its flame extinguished, even though the tube was furnished with the wire when the pressure was below 1-4th.

The flame of carbonic oxide, which, though it produces little heat in combustion, is as accendible as hydrogen, burned when the wire was used, the pressure being 1-6th.

The flame of sulphuretted hydrogen, the heat of which is in some measure carried off by the sulphur produced by its decomposition during its combustion in rare air, when burned in the same apparatus as the olefiant and other gases, was extinguished when the pressure was 1-7th.

Sulphur, which requires a lower temperature for its accension than any common inflammable substance, except phosphorus, burned with a very feeble blue flame in air rarefied 15 times; and at this pressure the flame heated a wire of platinum to dull redness; nor was it extinguished till the pressure was reduced to 1-20th. From the preceding experimental facts we may infer, that the taper would be extinguished at a height of between 9 and 10 miles, hydrogen between 12 and 13, and sulphur between 15 and 16.

Phosphorus, as has been shown by M. Van Marum, burns in an atmosphere rarefied 60 times. Sir H. Davy found, that phosphuretted hydrogen produced a flash of light when admitted into the best vacuum that could be made by an excellent pump of Nairne's construction.

Chlorine and hydrogen inflame at a much lower temperature than oxygen and hydrogen. Hence, the former mixture explodes when rarefied 24 times; the latter ceases to explode when rarefied 18 times. Heat extrinsically applied carries on combustion when it would otherwise be extinguished. Camphor, in a thick metallic tube, which disperses the heat, ceases to burn in air rarefied 6 times; in a glass tube which becomes ignited, the flame of camphor exists under a ninefold rarefaction. Contact with a red-hot iron makes naphtha glow with a lambent flame at a rarefaction of 30 times; though without foreign heat, its flame dies at an atmospheric rarefaction of 6. If the mixture of oxygen and hydrogen, expanded to its non-explosive tenuity, be exposed to the ignition of a glass tube, the electric spark will then cause an explosion, at least in the heated portion of the gases.

We shall now detail briefly the effects of rarefaction by *heat* on combustion and explosion. Under Caloric we have shown, that air, by being heated from 32° to 212° expands 3-8ths, or 8 parts become 11. Sir H. Davy justly estimates the temperature corresponding to an increase of one volume of air at 212°, into 2½ volumes (which took place when the enclosing glass tube began to soften with ignition), at 1035° Fahr.

Sir H. introduced into a small glass tube, over well boiled mercury, a mixture of two parts of hydrogen and one of oxygen, and heated the tube by a spirit-lamp, till the volume of the gas was increased from 1 to 2.5. By means of a blowpipe and another lamp, he made the upper part of the tube red-hot, when an explosion instantly took place. This experiment refutes the notions of M. de Grotthus, on the non-explosiveness of that mixture, when expanded by heat. He introduced into a bladder a mixture of oxygen and hydrogen, and connected this bladder with a thick glass tube of about one-sixth of an inch in diameter, and three feet long, curved so that it could be gradually heated in a charcoal furnace: two spirit-lamps were placed under the tube, where it entered the charcoal fire, and the mixture was very slowly passed through. An explosion took place before the tube was red-hot. This fine experient shows, that expansion by heat, instead of diminishing the accendibility of gases, enables them, on the contrary, to explode apparently at a lower temperature; which seems perfectly reasonable, as a part of the heat communicated by any ignited body must be lost in gradually raising the temperature.

M. de Grotthus has stated, that if a glowing coal be brought into contact with a mixture of oxygen and hydrogen, it only rarefies them, but does not explode them. This depends on the degree of heat communicated by the coal. If it is red in day-light, and free from ashes, it uniformly explodes the mixture. If its redness be barely visible in the shade, it will not explode them, but cause their slow combination. The general phenomenon is wholly unconnected with rarefaction, as is shown by the following circumstance: When the heat is greatest, and before the invisible combination is completed, if an iron wire, heated to whiteness, be placed upon the coal within the vessel, the mixture instantly explodes.

Subcarburetted hydrogen, or fire-damp, as has been shown, requires a very strong heat for its inflammation. It therefore offered a good substance for an experiment on the effect of high degrees of rarefaction, by heat, on combustion. One part of this gas, and eight of air, were mixed together, and introduced into a bladder furnished with a capillary tube. This tube was heated till it began to melt. The mixture was then passed through it into the flame of a spirit-lamp, when it took fire, and burned with its own peculiar explosive light, beyond the flame of the lamp; and when withdrawn, though the aperture was quite white-hot, it continued to burn vividly.

That the compression in one part of an explosive mixture, produced by the sudden expansion of another part by heat, or the electric spark, is not the cause of combustion, as has been supposed by Mr. Higgins, M. Berthollet, and others, appears to be evident from what has been stated, and is rendered still more so by the following facts: A mixture of biphosphuretted hydrogen gas and oxygen, which explode at a heat a little above that of boiling water, was confined by mercury, and very gradually heated on a sand bath. When the temperature of the mercury was 242°, the mixture exploded. A similar mixture was placed in a receiver communicating with a condensing syringe, and condensed over mercury till it occupied only one-fifth of its original volume. No explosion took place, and no chemical change had occurred; for when its volume was restored, it was instantly exploded by the spirit-lamp.

It would appear then that *the heat* given out by the compression of gases, is the real cause of the combustion which it produces; and that at certain elevations of temperature, whether in rarefied or compressed atmospheres, explosion or combustion occurs; that is, bodies combine with the production of heat and light.

Since it appears that gaseous matter acquires a double, triple, quadruple, &c. bulk, by the successive increments of 480° F. 2 × 480°, 3 × 480°, &c. we may gain approximations to the temperature of flame, by measuring the expansion of a gaseous mixture at the instant of explosion, provided the resulting compound gas occupy, after cooling, the same bulk as the sum of its constituents. Now this is the case with chlorine and hydrogen, and with cyanogen and oxygen. The latter detonated in the proportion of one to two in a tube of about two-fifths of an inch diameter, displaced a quantity of water, which demonstrated an expansion of 15 times their original bulk. Hence 15 × 480° = 7200° of Fahr.; and the real temperature is probably much higher, for heat must be lost by communication to the tube and the water. The heat of the gaseous carbon in combustion in this gas appears more intense than that of hydrogen; for it was found that a filament of platinum was fused by a flame of prussine (cyanogen) in the air, which was not fused by a similar flame of hydrogen.

We have thus detailed the modifications produced in combustion by rarefaction, mechanical and calorific. It remains on this head to state the effects of the mixture of different gases, and those of different cooling orifices, on flame.

In Sir H. Davy's first paper on the fire-damp of coal mines, he mentioned that carbonic acid had a greater influence in destroying the explosive power of mixtures of fire-damp and air, than azote; and he supposed the cause to be its greater density and capacity for heat, in consequence of which it might exert a greater cooling agency, and thus prevent the temperature of the mixture from being raised to that degree necessary for combustion. He subsequently made a series of experiments with the view of determining how far this idea is correct, and for the purpose of ascertaining the general phenomena of the effects of the mixture of gaseous substances upon explosion and combustion.

He took given volumes of a mixture of two parts of hydrogen and one part of oxygen by measure, and diluting them with various quantities of different elastic fluids, he ascertained at what degree of dilution the power of inflammation by a strong spark from a Leyden phial was destroyed. He found that for one of the mixture, inflammation was

	Prevented by	Permitted with	Cooling power, air = 1.
Of hydrogen	8	6	2.66
Oxygen,	9	7	1·12
Nitrous oxide,	11	10	0.75 (the mean)
Subcarburetted hydrogen,	1	$\frac{3}{4}$	2.18 (coal gas)
Sulphuretted hydrogen,	2	$1\frac{1}{2}$	
Olefiant gas,	$\frac{1}{2}$	$\frac{1}{3}$	1.6
Muriatic acid gas,	2	$1\frac{1}{2}$	
Chlorine,	. . .	. . .	0.66
Silicated fluoric gas,	$\frac{10}{12}$	$\frac{9}{12}$	
Azote,	. . .	. . .	1.33
Carbonic acid	. . .	. . .	0.727

The first column of the preceding table shows, that other causes, besides density and capacity for heat, interfere with the phenomena. Thus nitrous oxide, which is nearly one-third denser than oxygen, and which, according to Delaroche and Berard, has a greater capacity for heat, in the ratio of 1.3503 to 0.9765 by volume, has lower powers of preventing explosion. Hydrogen also, which is fifteen times lighter than oxygen, and which in equal volumes has a smaller capacity for heat, certainly has a higher power of preventing explosion; and olefiant gas exceeds all other gaseous substances, in a much higher ratio than could have been expected from its density and capacity.

I have deduced the third column, from Sir H. Davy's experiments, on the relative times in which a thermometer, heated to 160°, when plunged into a volume of 21 cubic inches of the respective gases at 52°, took to cool down to 106°. Where an elastic fluid exerts a cooling influence on a solid surface, the effect must depend principally upon the rapidity with which its particles change their places; but where the cooling particles are mixed throughout a mass with other gaseous particles, their effect must depend principally upon the power they possess of rapidly abstracting heat from the contiguous particles; and this will depend probably upon two causes, the simple abstracting power by which they become quickly heated, and their capacity for heat, which is great in proportion as their temperatures are less raised by this abstraction. The power of elastic fluids to abstract heat from solids, appears from the above experiments to be in some inverse ratio to their density; and there seems to be something in the constitution of the light gases, which enables them to carry off heat from solid surfaces in a different manner from that in which they would abstract it in gaseous mixtures, depending probably on the mobility of their parts. Those particles which are lightest must be conceived most capable of changing place, and would therefore cool solid surfaces most rapidly: in the cooling of gaseous mixtures, the mobility of the particles can be of little consequence.

Whatever be the cause of the different cooling powers of the different elastic fluids in preventing inflammation, very simple experiments show that they operate uniformly with respect to the different species of combustion; and that those explosive mixtures, or inflammable bodies, which require least heat for their combustion, require larger quantities of the different gases to prevent the effect, and *vice versa*. Thus one of chlorine and one of hydrogen still inflame when mixed with eighteen times their bulk of oxygen; whereas a mixture of carburetted hydrogen and oxygen, in the proper proportions (one and two) for combination, have their inflammation prevented by less than three times their volume of oxygen. A wax taper was instantly extinguished in air mixed with one-tenth of silicated fluoric acid, and in air mixed with one-sixth of muriatic acid gas; but the flame of hydrogen burned readily in those mixtures; and in mixtures which extinguished the flame of hydrogen, the flame of sulphur burned. (*See the beginning of section* 1*st*).

In cases, however, in which the heat required for chemical union is very small, as in the instance of hydrogen and chlorine, a mixture which prevents inflammation will not prevent combination; that is, the gases will combine without any flash. If two volumes of carburetted hydrogen be added to a mixture of one of chlorine with one of hydrogen, muriatic acid is formed throughout the mixture, and heat produced, as was evident from the expansion when the spark passed, and the rapid contraction afterwards; but the heat was so rapidly carried off by the quantity of carburetted hydrogen, that no flash was visible.

Experiments on combustion in condensed air, to see if the cooling power was much increased thereby, show that, as rarefaction does not diminish considerably the heat of flame in atmospherical air, so neither does condensation considerably increase it; a circumstance of great importance in the constitution of our atmosphere, which at all heights or depths, at which man can exist, still preserves the same relations to combustion.

It may be concluded from the general law, that, at high temperatures, gases not concerned in combustion will have less power of preventing that operation, and likewise that steam and vapours, which require a considerable heat for their formation, will have less effect in preventing combustion, particularly of those bodies requiring low temperatures, than gases at the usual heat of the atmosphere. Thus a very large quantity of steam is required to prevent sulphur from burning. A mixture of oxygen and hydrogen will explode by the electric spark, though diluted with five times its volume of steam; and even a mixture of air and carburetted hydrogen gas, the least explosive of all mixtures, requires a third of steam to prevent its explosion, whereas one-fifth of azote will produce that effect. These trials were made over mercury. Heat was applied to water over the mercury, and 37.5 for 100 parts = $\frac{3}{8}$, was regarded as the correction for the expansion of the gases.

We shall now treat of the effects of cooling orifices on flame. The knowledge of the cooling power of elastic *media*, in preventing the explosion of the fire-damp, led the illustrious English chemist to those practical researches which terminated in his grand discovery of the wire-gauze safe-lamp. The general investigation of the relation and extent of those powers, serves to elucidate the operation of wire-gauze, and other tissues or systems of apertures permeable to light and air, in intercepting flame, and confirms the views originally given of this marvellous phenomenon. We have seen that *flame* is gaseous matter, heated so highly as to be luminous, and *that* to a degree of temperature beyond the white heat of solid bodies; for air not luminous will communicate this degree of heat. When an attempt is made to pass flame through a very fine mesh of wire-gauze of the common temperature, the gauze cools each portion of the elastic matter that passes through it, so as to reduce its temperature below that degree at which it is luminous. This diminution of temperature is proportional to the smallness of the mesh, and to the mass of the metal. The power of a metallic or other tissue to prevent explosion, will depend upon the heat required to produce the combustion, as compared with that acquired by the tissue. Hence, the flame of the most inflammable substances, and of those that produce most heat in combustion, will pass through a metallic tissue, that will interrupt the flame of less inflammable substances, or those that produce little heat in combustion. Or, the tissue being the same, and impermeable to all flames at common temperatures, the flames of the most combustible substances, and of those which produce most heat, will most readily pass through it when it is heated, and each will pass through it at a different degree of temperature. In short, all the circumstances which apply to the effect of cooling mixtures upon flame will apply to cooling perforated surfaces. Thus, the flame of phosphuretted hydrogen, at common temperatures, will pass through a tissue sufficiently large, not to be immediately choaked up by the phosphoric acid formed, and the phosphorus deposited. If a tissue, containing above 700 apertures to the square inch, be held over the flame of phosphorus or phosphuretted hydrogen, it does not transmit the flame till it is sufficiently heated to enable the phosphorus to pass through it in vapour.* Phosphuretted hydrogen is decomposed by flame, and acts exactly like phosphorus. In like manner, a tissue of 100 apertures to the square inch, made of a wire of one-sixtieth, will, at common temperatures, intercept the flame of a spirit-lamp, but not that of hydrogen. But when strongly heated, it no longer arrests the flame of alcohol. A tissue which will not interrupt the flame of hydrogen when red-hot will still intercept that of olefiant gas; and a heated tissue, which would communicate explosion from a mixture of olefiant gas and air will stop an explosion from a mixture of fire-damp, or carburetted hydrogen. The latter gas requires a considerable mass of heated metal to inflame it, or contact with an extensive heated surface. An iron-wire of 1-20th of an inch, and eight inches long, red-hot, when held perpendicularly in a stream of coal gas, did not inflame it; nor did a short wire of one-sixth of an inch produce the effect, when held horizontally. But wire of the latter size, when six inches of it were red-hot, and when it was held perpendicularly in a bottle containing an explosive mixture, so that heat was communicated successively to portions of the gas, produced its explosion.

The scale of gaseous accension, given in the first section, explains why so fine a mesh of wire is required to hinder the explosion from hydrogen and oxygen to pass; and why so coarse a texture and wire control the explosion of fire-damp. The general doctrine, indeed, of the operation of wire-gauze, cannot be better elucidated, than in its effects upon the flame of sulphur. When wire-gauze of 600 or 700 apertures to the square inch, is held over the flame, fumes of condensed sulphur immediately come through it, and the flame is intercepted. The fumes continue for some instants, but on the increase of the heat, they diminish; and at the moment when they disappear, which is long before the gauze becomes red-hot, the flame passes; the temperature at which sulphur burns being that at which it is gaseous.

Where rapid currents of explosive mixtures, however, are made to act upon wire-gauze, it is of course much more rapidly heated; and therefore, the same mesh which arrests the flames of explosive mixtures at rest, will suffer them to pass when in rapid motion. But, by increasing the cooling surface, by diminishing the apertures in size, or increasing their depth, *all flames, however rapid their motion, may be arrested.* Precisely the same law applies to explosions acting in close vessels. Very minute apertures, when they are only few in number, will permit explosions to pass, which are arrested by much larger apertures when they fill a whole surface. A small aperture was drilled at the bottom of a wire-gauze lamp, in the cylindrical ring, which confines the gauze. This, though less than 1-18th of an inch in diameter, transmitted the flame, and fired the external atmosphere, in consequence of the whole force of the explosion of the thin stratum of the mixture included within the cylinder driving the flame through the aperture. Had the whole ring, however, been composed of such apertures separated by wires, it would have been perfectly safe.

Nothing can demonstrate more decidedly, than these simple facts and observations, that the interruption of flame, by solid tissues, permeable to light and air, depends upon no recondite or mysterious cause, but on their cooling powers, simply considered as such. When a light, included in a cage of wire-gauze, is introduced into an explosive atmosphere of fire-damp at rest, the maximum of heat is soon obtained: the radiating power of the wire, and the cooling effect of the atmosphere, more efficient from the admixture of inflammable air, prevent it from ever arriving at a temperature equal to that of dull redness. In rapid currents of explosive mixtures of fire-damp, which heat common gauze to a higher temperature, twilled gauze, in which the radiating surface is considerably greater, and the circulation of air less, preserves an equable temperature. Indeed, the heat communicated to the wire by combustion of the fire-damp in wire-gauze lamps, is completely in the power of the manufacturer. By diminishing the apertures, and increasing the mass of metal, or the radiating surface, it may be diminished to any extent. Thick twilled gauze, made of wires 1-40th, 16 to the warp, and 30 to the weft, riveted to the screw to prevent the possibility of displacement, forms a lamp cage, which, from its flexibility, cannot be broken, and from its strength cannot be crushed, except by a very violent blow. The lamp which has been found most convenient for the miner, is that composed of a cylinder of strong wire-gauze, fastened round the flame by a screw, and in which the wick is trimmed by a wire passing through a safe aperture. Such have now been used for many years, in the most dangerous mines of England, without any accident. Whatever explosive disasters have happened since may be imputed to the neglect, or gross and culpable mismanagement, of that infallible protector. See Lamp.

When the fire-damp is inflamed in the wire-gauze cylinders, coal dust thrown into the lamp burns with strong flashes and scintillations. The miners were at first alarmed by an effect of this kind, produced by the dust naturally raised during the working of the coals.

But Sir H. Davy showed, by decisive experiments, that explosion could never be communicated by them to the gas of any mine. He repeatedly threw coal-dust, powdered rosin, and witch-meal, through lamps burning in more explosive mixtures than ever occur in coal mines; and though he kept these substances floating in the explosive atmosphere, and heaped them upon the top of the lamp when it was red-hot, no explosion could ever be communicated. Phosphorus or sulphur are the only substances which can produce explosion, by being applied to the outside of the lamp; and sulphur, to produce the effect, must be applied in large quantities, and fanned by a current of fresh air. He has even blown repeatedly fine coal dust mixed with minute quantities of the finest dust of gunpowder, through the lamp burning in explosive mixtures, without any communication of explosion. The most timorous female might traverse an explosive coal mine, guided by the light of the double cylinder lamp, without feeling the slightest apprehension.

5. We have now arrived at the most curious of all Sir H.'s discoveries relative to fire, namely, *invisible combustion.*

On passing mixtures of hydrogen and oxygen through tubes heated below redness, steam appeared to be formed without any combustion. This led him to expose mixtures of oxygen and hydrogen to heat, in tubes, in which they were confined by fluid fusible metal. He found, that by carefully applying a heat between the boiling point of mercury, which is not sufficient for the effect, and a heat approaching to the greatest heat that can be given without making glass luminous in darkness, the combination was effected without any violence, and without any light; and commencing with 212, the volume of steam formed at the point of combination appeared exactly equal to that of the original gases. So that the first effect, in experiments of this kind, is an expansion, afterwards a contraction, and then the restoration of the primitive volume.

When this change is going on, if the heat be quickly raised to redness, an explosion takes place. With small quantities of gas, the invisible combustion is completed in less than a minute. It is probable that the slow combination without combustion, long ago observed with respect to hydrogen and chlorine, oxygen and metals, will happen at certain temperatures with most substances that unite by heat. On trying charcoal, he found, that at a temperature which appeared to be a little above the boiling point of quicksilver, it converted oxygen pretty rapidly into carbonic acid, without any luminous appearance; and at a dull red heat, the elements of olefiant gas combined in a similar manner with oxygen, slowly and without explosion. The effect of the slow combination of oxygen and hydrogen is not connected with their rarefaction by heat, for it took place when the gases were confined in a tube by fusible metal, rendered solid at its upper surface; and certainly as rapidly, and without any appearance of light.

As the temperature of flame has been shown to be infinitely higher than that necessary for the ignition of solid bodies, it appeared probable, that in these silent combinations of gaseous bodies, when the increase of temperature may not be sufficient to render the gaseous matters themselves luminous, yet it still might be adequate to ignite solid matters exposed to them.

Sir H. Davy had devised several experiments on this subject. He had intended to expose fine wires to oxygen and olefiant gas, and to oxygen and hydrogen, during their slow combination under different circumstances, when he was accidentally led to the knowledge of the *fact*, and at the same time to the discovery of a new and curious series of phenomena.

He was making experiments on the increase of the limits of the combustibility of gaseous mixtures of coal gas and air, by increase of temperature. For this purpose, a small wire-gauze safe-lamp, with some fine wire of platinum fixed above the flame, was introduced into a combustible mixture, containing the maximum of coal gas. When the inflammation had taken place in the wire-gauze cylinder, he threw in more coal gas, expecting that the heat acquired by the mixed gas, in passing through the wire-gauze, would prevent the excess from extinguishing the flame. The flame continued for two or three seconds after the coal gas was introduced; and when it was extinguished, that part of the wire of platinum which had been hottest, remained ignited, and continued so for many minutes. When it was removed into a dark room, it was evident that there was no flame in the cylinder.

It was immediately obvious that this was the result which he had hoped to attain by other methods, and the oxygen and coal gas in contact with the hot wire combined without flame, and yet produced heat enough to preserve the wire ignited, and keep up their own *secret combustion*. The truth of this conclusion was proved by introducing a heated wire of platinum into a similar mixture. It immediately became ignited nearly to whiteness, as if it had been in actual combustion itself, and continued glowing for a long while. *When it was extinguished, the inflammability of the mixture was found to be entirely destroyed.* A temperature much below ignition only was necessary for producing this curious phenomenon, and the wire was repeatedly taken out and cooled in the atmosphere till it ceased to be visibly red; yet when admitted again, it instantly became red-hot.

The same phenomena were produced with mixtures of olefiant gas and air, carbonic oxide, prussic gas, and hydrogen; and in this last case with a rapid production of water. The degree of heat could be regulated by the thickness of the wire. When of the same thickness, the wire became more ignited in hydrogen than in mixtures of olefiant gas, and more in mixtures of olefiant gas than in those of gaseous oxide of carbon.

When the wire was very fine, as 1·80th of an inch in diameter, its heat increased in very combustible mixtures, so as to explode them. The same wire in less combustible mixture continued merely bright red, or dull red, according to the nature of the mixture. In mixtures not explosive by flame within certain limits, these curious phenomena took place, whether the air or the inflammable gas was in excess. The same circumstances occurred with certain inflammable vapours. Those of ether, alcohol, oil of turpentine, naphtha, and camphor, have been tried. There cannot be a better mode of illustrating the fact, than by an experiment on the vapour of ether or of alcohol, which any person may make in a minute. Let a drop of ether be thrown into a cold glass, or a drop of alcohol into a warm one; let a few coils of wire of platinum, of the 1-60th or 1-70th of an inch, be heated at a hot poker or a candle, and let it be brought into the glass: In some part of the glass it will become glowing, almost white-hot, and will continue so, as long as a sufficient quantity of vapour and of air remain in the glass.

When the experiment on the slow combustion of ether is made in the dark, a pale phosphorescent light is perceived above the wire, which is of course most distinct when the wire ceases to be ignited. This appearance is connected with the formation of a peculiar acrid volatile substance, possessed of acid properties. See ACID (LAMPIC). The above experiment has been ingeniously varied by sticking loosely on the wick of a spirit-lamp a coil of fine platinum wire, about $\frac{1}{100}$ of an inch in thickness. There should be about 16 spiral turns, one-half of which should surround the wick, and the other rise above it. Having lighted the lamp for an instant, on blowing it out, the wire will become brightly ignited, and will continue to glow as long as any alcohol remains. A cylinder of camphor may be substituted for both wick and spirit. The ignition is very bright, and exhales an odoriferous vapour. With oil of turpentine, the lamp burns invisibly without igniting the wire; for a dense column of vapour is perceived to ascend from the wire, diffusing a smell by many thought agreeable. By adding essential oils in small quantities to the alcohol, various *aromas* may be made to perfume the air of an apartment. But the film of charcoal which in this case collects on the platina coil must be removed by ignition over another spirit flame, otherwise the effect ceases after a certain time.

The chemical changes in general produced by slow combustion appear worthy of investigation. A wire of platinum introduced under the usual circumstances into a mixture of prussic gas (cyanogen) and oxygen in excess, became ignited to whiteness, and the yellow vapours of nitrous acid were observed in the mixture. In a mixture of olefiant gas, non-explosive from the excess of inflammable gas, much carbonic oxide was formed. Platinum and palladium, metals of low conducting powers, and small capacities for heat, alone succeed in producing the above phenomena. A film of carbon or sulphur deprives even these metals of this property. Thin laminæ of the metals, if their form admits of a free circulation of air, answer as well as fine wires; and a large surface of platinum may be made red-hot in the vapour of ether, or in a combustible mixture of coal gas and air.

Sir H. Davy made an admirable practical application of these new facts. By hanging some coils of fine platinum wire, or a fine sheet of platinum or palladium, above the wick of the safe-lamp in the wire-gauze cylinder, he has supplied the coal-miner with light in mixtures of fire-damp no longer explosive. Should the flame be extinguished by the quantity of fire-damp, the glow of the platinum will continue to guide him; and by placing the lamp in different parts of the gallery, the relative brightness of the wire will show the state of the atmosphere in these parts. Nor can there be any danger with respect to respiration wherever the wire continues ignited; for even this phenomenon ceases, when the foul air forms about $\frac{2}{5}$ of the volume of the atmosphere.

Into a wire-gauze safe-lamp, a small cage made of fine wire of platinum, of 1-70th of an inch in thickness, was introduced, and fixed by means of a thick wire of platinum, about 2 inches above the lighted wick. This apparatus was placed in a large receiver, in which, by means of a gas-holder, the air could be contaminated to any extent with coal gas. As soon as there was a slight admixture of coal gas, the platinum became ignited. The ignition continued to increase till the flame of the wick was extinguished, and till the whole cylinder became filled with flame. It then diminished. When the quantity of coal gas was increased so as to extinguish the flame, the cage of platinum, at the moment of the extinction, became white-hot, presenting a most brilliant light. By increasing the quantity of the coal gas still further, the ignition of the platinum became less vivid. When its light was barely sensible, small quantities of air were admitted, and it speedily increased. By regulating the admission of coal gas and air, it again became white-hot, and soon after lighted the flame in the cylinder, which as usual, by the addition of more atmospheric air, rekindled the flame of the wick.

This beautiful experiment has been very often repeated, and always with the same results. When the wire for the support of the cage, whether of platinum, silver, or copper, was very thick, it retained sufficient heat to enable the fine platinum wire to rekindle in a proper mixture, *half a minute* after its light had been entirely destroyed by an atmosphere of pure coal gas. The phenomenon of the ignition of the platinum takes place feebly in a mixture consisting of two of air and one of coal gas; and brilliantly in a mixture consisting of three of air and one of coal gas. The greater the quantity of heat produced, the greater may be the quantity of the coal gas, so that a large tissue of wire made white-hot will burn in a more inflammable mixture (that is, containing more inflammable gas) than one made red-hot. If a mixture of three parts of air and one of fire-damp be introduced into a bottle, and inflamed at its point of contact with the atmosphere, it will not explode, but will burn like a pure inflammable substance. If a fine wire of platinum, coiled at its end, be slowly passed through the flame, it will continue ignited in the body of the mixture, and the same gaseous matter will be found to be *inflammable*, and to be a *supporter* of combustion. When a large cage of wire of platinum is introduced into a very small safe-lamp, even explosive mixtures of fire-damp are burned without flame; and by placing any cage of platinum in the bottom of the lamp round the wick, the wire is prevented from being smoked. Care should be taken, of course, that no filament of the platinum protrude through the wire-gauze. It is truly wonderful, that a slender tissue of platinum, which does not cost one shilling, and which is imperishable, should afford in the dark and dangerous recesses of a coal mine, a most *brilliant light*, perfectly safe, in atmospheres in which the flame of the safety-lamp is extinguished; and which glows in every mixture of carburetted hydrogen gas that is respirable. When the atmosphere becomes again explosive, the *flame* is relighted.

It is no less surprising, that thus also we can burn any inflammable vapour, either with or without flame, at pleasure, and make a slender wire consume it, either with a white or red heat.

6. We shall conclude the subject of combustion with some practical inferences.

The facts detailed on insensible combustion, explain why so much more heat is obtained from fuel when it is burned quickly, than slowly; and they show that in all cases the temperature of the acting bodies should be kept as high as possible, not only because the general increment of heat is greater, but likewise because those combinations are prevented, which, at lower temperatures, take place without any considerable production of heat. Thus in the argand lamp, and in the best fire-places, the increase of effect does not depend merely upon the rapid current of air, but likewise upon the heat preserved by the arrangement of the materials of the chimney, and communicated to the matters entering into inflammation.

These facts likewise explain the source of the great error into which Mr. Dalton has fallen, in estimating the heat given out in the combustion of charcoal; and they indicate methods by which temperature may be increased, and the limits to certain methods. Currents of flame can never raise the heat of bodies exposed to them higher than a certain degree, that is, their own temperature. But by compression, there can be no doubt, that the heat of flames from pure supporters and combustible matter may be greatly increased, probably in the ratio of their compression. In the blowpipe of oxygen and hydrogen, the maximum of temperature is close to the aperture from which the gases are disengaged, that is, where their density is greatest. Probably a degree of temperature far beyond any that has yet been attained may be produced by throwing the flame from compressed oxygen and hydrogen into the voltaic arc, and thus combining the two most powerful agents for increasing temperature.

The nature of the light, and form, of flames, can now be clearly understood. When in flames pure *gaseous* matter is burnt, the light is extremely feeble. The density of a common flame is proportional to the quantity of solid charcoal first deposited, and afterwards burned. The form of the flame is conical, because the greatest heat is in the centre of the explosive mixture. In looking steadfastly at flame, the part where the combustible matter is volatilized is seen, and it appears dark, contrasted with the part in which it begins to burn; that is, where it is so mixed with air as to become explosive. The heat diminishes towards the top of the flame, because in this part the quantity of oxygen is least. When the wick increases to a considerable size, from collecting charcoal, it cools the flame by radiation, and prevents a proper quantity of air from mixing with its central part; in consequence, the charcoal thrown off from the top of the flame is only red-hot, and the greater part of it escapes unconsumed.

The intensity of the *light* of flames in the atmosphere is increased by condensation, and diminished by rarefaction, apparently in a higher ratio than their *heat:* more particles capable of emitting light exist in the denser atmospheres, and yet most of these particles, in becoming capable of emitting light, absorb heat, which could not be the case in the condensation of a pure supporting medium.

The facts on rarefaction of inflammable gases show, that the luminous appearances of shooting stars and meteors cannot be owing to any inflammation of *elastic* fluids, but must depend on the ignition of *solid* bodies. Dr. Halley calculated the height of a meteor at ninety miles, and the great American meteor, which threw down showers of stones, was estimated at seventeen miles high. The velocity of motion of these bodies must in all cases be immensely great, and the heat produced by the compression of the most rarefied air, from the velocity of motion, must be probably sufficient to ignite the mass. All the phenomena may be explained, if *falling* stars be supposed to be small solid bodies moving round the earth in very eccentric orbits, which become ignited only when they pass with immense velocity through the upper regions of the atmosphere; and if the *meteoric bodies* which throw down stones with explosions, be supposed to be similar bodies which contain either combustible or elastic matter.

When the *common* electrical or *voltaic* electrical spark is taken in rare air, the light is considerably diminished, as well as the heat. Yet in a receiver that contained air 60 times rarer than that of the atmosphere, a piece of wire of platinum, placed by Sir H. Davy in the centre of the luminous arc produced by the great voltaic apparatus of the Royal Institution, became white-hot; and that this was not owing to the electrical conducting powers of the platinum, was proved by repeating the experiment with a filament of glass, which instantly fused in the same position. It is evident from this, that electrical heat and light may appear in atmospheres, in which the flame of combustible bodies could not exist; and the fact is interesting from its possible application in explaining the phenomena of the *Aurora Borealis* and *Australis.*

Finally, we may establish it as an axiom, that combustion is not the great phenomenon of chemical nature; but an adventitious accidental accessory to chemical combination, or *decomposition; that is, to the internal motions of the particles of bodies, tending to arrange them in a new chemical constitution.*

Several cases of death, from spontaneous combustion of the body, are on record. The appearances resemble those which would be produced by phosphuretted hydrogen.

COMPTONITE. A new mineral found in drusy cavities, in ejected masses, on Mount Vesuvius. It occurs crystallized, in oblique four-sided prisms, which are usually truncated on their lateral edges, so as to form eight-sided prisms, terminated with flat summits. The angles of the oblique prism are probably 90° 51′ and 88° 9′. Transparent, or semi-transparent. Gelatinizes with acids. It is sometimes accompanied with acicular Arragonite. It was first brought to this country by Lord Compton, in 1818.

CONCRETIONS (MORBID). Solid deposites, formed by disease in the soft parts, or in the cavities of animal bodies. The former are usually called *ossifications*, as they seem to consist of calcareous phosphate. They are named, according to the part in which they are deposited, pineal, salivary, pulmonary, pancreatic, hepatic, prostatic, gouty. Deposites in *cavities* are generally styled calculi, from their resemblance to pebbles. These are intestinal, gall-stones or biliary, renal, and urinary. *See the respective articles.*

CONGELATION. In addition to the methods pointed out under Caloric, for effecting artificial congelation, we shall here describe the elegant mode by the air-pump, recently introduced by Professor Leslie.

The very ingenious Dr. Cullen seems to have been the first who applied the vacuum of an air-pump to quicken the evaporation of liquids, with a view to the abstraction of heat, or artificial congelation. In the year 1755, he plunged a full phial of ether into a tumbler of water, and on placing it under the receiver, and exhausting the air, the ether boiled, and the surrounding water froze.

In the year 1777, Mr. Edward Nairne, a very eminent London optician, published in the Transactions of the Royal Society, "an account of some experiments made with an air-pump." After stating, that at a certain point of rarefaction the moisture about the pump furnished an atmosphere of vapour, which affected his comparative results with the mercurial gauge and pear gauge, he says, "I now put some sulphuric acid into the receiver, as a means of trying to make the remaining contents of the receiver, when exhausted as much as possible, to consist of permanent air only, *unadulterated with vapour*." He was thus enabled by this *artificial dryness* to exhibit certain electrical phenomena to great advantage. The next step which Mr. Nairne took, was to produce *artificial cold* by the air-pump. "Having lately received from my friend Dr. Lind," he says, "some ether prepared by the ingenious Mr. Woolfe, I was very desirous to try whether I could produce any considerable degree of cold by the evaporation of ether under a receiver whilst exhausting." Accordingly he succeeded in sinking a thermometer, whose bulb was from time to time dipped into the ether *in vacuo*, 103° below 56°, the temperature of the apartment. Mr. Nairne made no attempt to condense the vapour *in vacuo* by chemical means, and thus to favour its renewed formation from the liquid surface; which I consider to be the essence of Professor Leslie's capital improvement on Cullen's plan of artificial refrigeration. After Nairne's removing the vapour of water by sulphuric acid to produce artificial *dryness*, there was indeed *but* a slight step to the production of artificial *cold*, by the very same arrangement; but still this *step* does not appear to have been attempted by any person from the year 1777 to 1810, when Professor Leslie was naturally led to make *it*, by the train of his researches on evaporation and hygrometry.

The extreme rapidity of evaporation *in vacuo* may be inferred from Dr. Robison's position, that all liquids boil in it, at a temperature 120° to 125° lower than their usual boiling point in the atmosphere. Could we find a liquid or solid substance which would rapidly imbibe alcohol, ether, or sulphuret of carbon, we would probably be able to effect reductions of temperature prodigiously greater than any hitherto reached. Water, however, has no doubt one advantage, in the superior latent heat of its vapour, which must compensate in a considerable degree for its inferior rapidity of vaporization.

In the month of June 1810, Professor Leslie having introduced a surface of sulphuric acid under the receiver of an air-pump, and also a watch-glass filled with water, he found, that after a few strokes of the pump, the water was converted into a solid cake of ice, which being left in the rarefied medium, continued to evaporate, and after the interval of about an hour totally disappeared. When the air has been rarefied 250 times, the utmost that under such circumstances can perhaps be effected, the surface of evaporation is cooled down 120° Fahrenheit in winter, and would probably, from more copious evaporation and condensation, sink near 200° in summer. If the air be rarefied only 50 times, a depression of 80°, or even 100°, will be produced.

We are thus enabled by this elegant combination, to freeze a mass of water in the hottest weather, and to keep it frozen, till it gradually wastes away, by a continued but invisible process of evaporation. The only thing required is, that the surface of the acid should approach tolerably near to that of the water, and should have a greater extent; for otherwise the moisture would exhale more copiously than it could be transferred and absorbed, and consequently the dryness of the rarefied medium would become reduced, and its evaporating energy essentially impaired. The acid should be poured to the depth of perhaps half an inch, in a broad flat dish, which is covered by a receiver of a form nearly hemispherical; the water exposed to congelation may be contained in a shallow cup, about half the width of the dish, and having its rim supported by a narrow porcelain ring, upheld above the surface of the acid by three slender feet. It is of consequence that the water should be insulated as much as possible, or should present only a humid surface to the contact of the surrounding medium; for the dry sides of the cup might receive, by radiation from the external air, such accessions of heat, as greatly to diminish, if not to counteract, the refrigerating effects of evaporation. This inconvenience is in a great measure obviated, by investing the cup with an outer case, at the interval of about half an inch. If both the cup and its case consist of glass, the process of congelation is viewed most completely; yet when they are formed of a bright metal, the effect appears, on the whole, more striking. But the preferable mode, and that which prevents any waste of the powers of refrigeration, is to expose the water in a saucer of porous earthen ware. At the instant of congelation, a beautiful network of icy spiculæ pervades the liquid mass.

The disposition of the water to fill the receiver with vapour, will seldom permit even a good air-pump to produce greater rarefaction than that indicated by 3-10ths of an inch of mercury, beneath the barometrical height, at the time. But every practical object may be obtained by more moderate rarefactions, and a considerable surface of acid. The process goes on more slowly, but the ice is very solid, especially if the water have been previously purged of its air by distillation, or boiling for a considerable time. If we use a receiver, with a sliding wire passing down from its top through a collar of leathers, and attach to it a disc of glass; on applying this to the surface of the water cup, we may instantly suspend the process of congelation; and raising the disc as suddenly, permit the advancement of the process.

In exhibiting the different modifications of this system of congelation to my pupils, I have been accustomed for many years to recommend the employment of a series of cast-iron plates, attachable by screws and stopcocks to the air-pump. Each iron disc has a receiver adapted to it. Thus we may, with one air-pump, successively put any number of freezing processes in action. A cast-iron drum of considerable dimensions being filled with steam, by heating a small quantity of water in it, will sufficiently expel the air for producing the requisite vacuum. When it is cooled by affusion of water, one of the above transferrer plates being attached to the stop-cock on its upper surface, would easily enable us, without any air-pump, to effect congelation by means of sulphuric acid, in the attenuated atmosphere. Suppose the capacity of the receiver to be 1-60th of the iron cylinder; an aeriform rarefaction to this degree would be effected in a moment by a turn of the stop-cock; and on its being returned, the moisture below would be cut off, and the acid would speedily condense the small quantity of vapour which had ascended.

This cheap and powerful plan was publicly recommended by me upwards of 16 years ago, when I had a glass model of it made for class illustration.

The combined powers of rarefaction, vaporization, and absorption, are capable of effecting the congelation of quicksilver. If this metal, contained in a hollow pear-shaped piece of ice, be suspended by cross threads near a broad surface of sulphuric acid, under a receiver; on urging the rarefaction, it will become frozen, and may be kept in the solid state for several hours. Or otherwise, having introduced mercury into the large bulb of a thermometer, and attached the stem to the sliding rod of the receiver, place this over the sulphuric acid and water cup on the air pump plate. After the air has been rarefied about 50 times, let the bulb be dipped repeatedly into the very cold but unfrozen water, and again drawn up about an inch. In this way it will become incrusted with successive coats of ice, to the twentieth of an inch thick. The cup of water being now withdrawn from the receiver, the pendent icicle cut away from the bulb, and the surface of the ice smoothed with a warm finger, the receiver is again to be replaced, and the bulb being let down within half an inch of the acid, the exhaustion must be pushed to the utmost. When the syphon-gauge arrives at the tenth of an inch, the icy crust opens with fissures, and the mercury having gradually descended in the tube, till it reach its point of congelation, or 39° below zero, sinks by a sudden contraction almost into the cavity of the bulb. The apparatus being now removed, and the ball speedily broken, the metal appears a solid shining mass, that will bear the stroke of a hammer. A still greater degree of cold may be produced, by applying the same process to cool the atmosphere which surrounds the receiver.

When the acid has acquired one-tenth of water, its refrigerating power is diminished only one-hundredth. When the quantity of moisture is equal to one-fourth of the concentrated acid, the power of generating cold is reduced by a twentieth; and when the dilution is one-half, the cooling powers become one-half or probably less. Sulphuric acid is hence capable of effecting the congelation of more than twenty times its weight of water, before it has imbibed nearly its own bulk of that liquid, or has lost about one-eighth of its refrigerating power. The acid should then be removed, and reconcentrated by heat.

The danger of using a corrosive acid in unskilful hands may be obviated by using oatmeal, desiccated nearly to brownness before a kitchen-fire, and allowed to cool in close vessels. With a body of this, a foot in diameter, and an inch deep, Professor Leslie froze a pound and a quarter of water, contained in a hemispherical porous cup. Muriate of lime in ignited porous pieces may also be employed as an absorbent. Even mouldering trap or whinstone has been used for experimental illustration with success.

By the joint operation of radiation and evaporation from the surface of water, the natives of India are enabled to procure a supply of ice, when the temperature of the air is many degrees *above* the freezing point. Not far from Calcutta, in large open plains, three or four excavations are made in the ground, about 30 feet square, and 2 feet deep, the bottom of which is covered to the thickness of nearly a foot with sugar canes, or dried stalks of Indian corn. On this bed are placed rows of small unglazed earthen pans, about an inch and a quarter deep, and somewhat porous. In the dusk of the evening, during the months of December, January, and February, they are filled with soft water, previously boiled and suffered to cool. When the weather is very fine and clear, a great part of the water becomes frozen during the night. The pans are regularly visited at sunrise, and their contents emptied into baskets which retain the ice. These are now carried to a conservatory made by sinking a pit 14 or 15 feet deep, lined with straw under a layer of coarse blanketing. The small sheets of ice are thrown down into the cavity, and rammed into a solid mass. The mouth of the pit is then closed up with straw and blankets, and sheltered by a thatched roof.

For some additional facts on this interesting subject, see the sequel of the article DEW.

CONGLOMERITE. A compound mineral mass in which angular fragments of rocks are imbedded. The Italian term *breccia* has the same meaning. In pudding-stone, the imbedded fragments are round, bearing the marks of having been polished by attrition.

CONITE. An ash or greenish-grey coloured mineral, which becomes brown on exposure to the air. It is massive or stalactitic, is dull internally, and has a small-grained uneven fracture. It is brittle: sp. gr. 2.85. It dissolves in nitric acid, with slight effervescence, and blackens without fusing before the blowpipe. Its constituents are 67.5 carbonate of magnesia, 28 carbonate of lime, 3.5 oxide of iron, and 1 water It is found in the Meissner trap hill in Hessia, in Saxony, and Iceland. Dr. Macculloch has given the name *Conite* to a pulverulent mineral, as fusible as glass into a transparent bead, which he found in Mull and Glenfarg, in the trap hills of Kilpatrick, and the Isle of Sky.

COPAL, improperly called *gum copal*, is a hard, shining, transparent, citron-coloured, odoriferous, concrete juice of an American tree; but which has neither the solubility in water common to gums, nor the solubility in alcohol common to resins, at least in any considerable degree. By these properties it resembles amber. It may be dissolved by digestion in linseed oil, rendered drying by quicklime, with a heat very little less than sufficient to boil or decompose the oil. This solution, diluted with oil of turpentine, forms a beautiful transparent varnish, which, when properly applied, and slowly dried, is very hard and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colours of old pictures, by filling up the cracks, and rendering the surfaces capable of reflecting light more uniformly.

Mr. Sheldrake has found, that camphor has a powerful action on copal; for if powdered copal be triturated with a little camphor, it softens, and becomes a coherent mass; and camphor added either to alcohol or oil of turpentine renders it a solvent of copal. Half an ounce of camphor is sufficient for a quart of oil of turpentine, which should be of the best quality; and the copal, about the quantity of a large walnut, should be broken into very small pieces, but not reduced to a fine powder. The mixture should be set on a fire so brisk as to make the mixture boil almost immediately; and the vessel Mr. S. recommends to be of tin or other metal, strong, shaped like a wine-bottle with a long neck, and capable of holding two quarts. The mouth should be stopped with a cork, in which a notch is cut to prevent the vessel from bursting. It is probably owing to the quantity of camphor it contains, that oil of lavender is a solvent of copal. Camphor and alcohol dissolve copal still more readily than camphor and oil of turpentine.

Lewis had observed, that solution of ammonia enabled oil of turpentine to dissolve copal; but it requires such nice management of the fire that it seldom succeeds completely.

In the 51st volume of Tilloch's Magazine, Mr. Cornelius Varley states, that a good varnish may be made by pouring upon the purest lumps of copal, reduced to a fine mass in a mortar, colourless spirits of turpentine, to about one-third higher than the copal, and triturating the mixture occasionally in the course of the day. Next morning it may be poured off into a bottle for use. Successive portions of oil of turpentine may thus be worked with the same copal mass. Camphorated oil of turpentine, and oil of spike lavender, are also recommended as separate solvents without trituration. The latter, however, though very good for drawings or prints, will not do for varnishing pictures, as it dissolves the paint underneath, and runs down while drying.

COPPER is a metal of a peculiar reddish-brown colour; hard, sonorous, very malleable, and ductile; of considerable tenacity, and of a specific gravity from 8.6 to 8.9. At a degree of heat far below ignition, the surface of a piece of polished copper becomes covered with various ranges of prismatic colours, the red of each order being nearest the end which has been most heated; an effect which must doubtless be attributed to oxidation, the stratum of oxide being thickest where the heat is greatest, and growing gradually thinner and thinner towards the colder part. A greater degree of heat oxidizes it more rapidly, so that it contracts thin powdery scales on its surface, which may be easily rubbed off; the flame of the fuel becoming at the same time of a beautiful bluish-green colour. In a heat, nearly the same as is necessary to melt gold or silver, it melts, and exhibits a bluish-green flame; by a violent heat it boils, and is volatilized partly in the metallic state.

Copper rusts in the air; but the corroded part is very thin, and preserves the metal beneath from farther corrosion.

We have two oxides of copper. The black, procurable by heat, or by drying the hydrated oxide precipitated by potash from the nitrate. It consists of 8 copper + 2 oxygen. It is a deutoxide. The protoxide is obtained by digesting a solution of muriate of copper with copper turnings, in a close phial. The colour passes from green to dark brown, and grey crystalline grains are deposited. The solution of these yields, by potash, a precipitate of an orange colour, which is the protoxide. It consists of 8 copper + 1 oxygen. Protoxide of copper has been lately found by Mr. Mushet, in a mass of copper, which had been exposed to heat for a considerable time, in one of the melting furnaces of the mint under his superintendence.

Copper, in filings, or thin laminæ, introduced into chlorine, unites with flame into the chloride, of which there are two varieties; the protochloride, a fixed yellow substance, and the deutochloride, a yellowish-brown pulverulent sublimate. 1. The crystalline grains deposited from the above muriatic solution are *protochloride*. The protochloride is conveniently made by heating together two parts of corrosive sublimate, and one of copper filings. An amber-coloured translucent substance, first discovered by Boyle, who called it resin of copper, is obtained. It is fusible at a heat just below redness; and in a close vessel, or a vessel with a narrow orifice, is not decomposed or sublimed by a strong red heat. But if air be admitted, it is dissipated in dense white fumes. It is insoluble in water. It effervesces in nitric acid. It dissolves silently in muriatic acid, from which it may be precipitated by water. By slow cooling of the fused mass Dr. John Davy obtained it crystallized, apparently in small plates, semitransparent, and of a light yellow colour. It consists, by the same ingenious chemist, of

Chlorine,	36	or 1 prime	= 4.5	36
Copper,	64	or 1 prime	8.0	64
	100		12.5	100

2. *Deutochloride* is best made by slowly evaporating to dryness, at a temperature not much above 400° Fahr. the deliquescent muriate of copper. It is a yellow powder. By absorption of moisture from the air, it passes from yellow to white, and then green, reproducing common muriate. Heat converts it into protochloride, with the disengagement of chlorine. Dr. Davy ascertained the chemical constitution of both these compounds, by separating the copper with iron, and the chlorine by nitrate of silver. The deutochloride consists of

Chlorine,	53	2 primes	9	53
Copper,	47	1 do.	8	47
	100		17	100

The *iodide* of copper is formed by dropping aqueous hydriodate of potash into a solution of any cupreous salt. It is an insoluble dark brown powder.

Phosphuret of copper is made by projecting phosphorus into red-hot copper. It is of a white colour, harder than iron, pretty fusible, but not ductile. Its sp. gr. is 7.12. It crystallizes in four-sided prisms. Proust, its discoverer, says it consists of 20 phosphorus + 80 copper. Phosphorus + 2 × 8.0 copper, form the equivalent proportions by theory. Heat burns out the phosphorus, and scorifies the copper.

Sulphuret of copper is formed by mixing together eight parts of copper filings, and two of sulphur, and exposing the mixture to a gentle heat. Whenever the sulphur is raised a little above its melting temperature, combustion suddenly pervades the whole mass with explosive violence.

Ignition, with reciprocal saturation, constitutes a true combustion, of which every character is here. And since the experiment succeeds perfectly well *in vacuo*, or in azote, we are entitled to consider sulphur as a true supporter of combustion, if this name be retained is chemistry; a name indicating what no person can prove, that one of the combining bodies is a mere supporter, and the other a mere combustible. Combustion is, on the contrary, shown by this beautiful experiment to be independent of those bodies vulgarly reckoned supporters. Indeed, sulphur bears to copper the same electrical relation that oxygen and chlorine bear to this metal. Hence sulphur is at once a supporter and a combustible, in the fullest sense; a fact fatal to this technical distinction, since one body cannot be possessed of opposite qualities.

When a disc of copper, with an insulated handle, is made to touch a disc of sulphur, powerful electrical changes ensue; and at a higher temperature we see, that the reciprocal attractive forces, or the corpuscular movements which accompany energetic affinity, excite the phenomena of combustion. To say that one of the combining bodies contains a latent magazine of heat and light, to feed the flame of the other body, is an hypothesis altogether destitute of proof, which should therefore have no place in one of the exact sciences, far less be made the ground-work of a chemical system.

Sulphuret of copper consists, according to Berzelius, of very nearly 8 copper + 2 sulphur. We may regard it as containing a prime of each constituent.

Sulphuric acid, when concentrated and boiling, dissolves copper. If water be added to this, it forms a blue solution of copper, which, by evaporation, affords blue crystals, that require about four times their weight of water to dissolve them.

The solutions of copper in sulphuric acid are slightly caustic. Magnesia, lime, and the fixed alkalis, precipitate the metal from them in the form of oxide. Volatile alkali precipitates all the solution of copper, but redissolves the oxide, and produces a deep blue colour. There are certain mineral waters in Hungary, Sweden, Ireland, and in various parts of England, which contain sulphate of copper, and from which it is precipitated by the addition of pieces of old iron.

Nitric acid dissolves copper with great rapidity, and disengages a large quantity of nitrous gas. Part of the metal falls down in the form of an oxide; and the filtrated or decanted solution, which is of a much deeper blue colour than the sulphuric solution, affords crystals by slow evaporation. This salt is deliquescent, very soluble in water, but most plentifully when the fluid is heated. Its solution, exposed to the air in shallow vessels, deposits an oxide of a green colour. Lime precipitates the metal of a pale blue, fixed alkalis of a bluish-white. Volatile alkali throws down bluish flocks, which are quickly redissolved, and produce a lively blue colour in the fluid.

The saline combinations of copper were formerly called *sales veneris*, because Venus was the mythological name of copper. They have the following general characters: 1. They are mostly soluble in water, and their solutions have a green or blue colour, or acquire one of these colours on exposure to air. 2. Ammonia added to the solutions, produces a deep blue colour. 3. Ferroprussiate of potash gives a reddish-brown precipitate, with cupreous salts. 4. Gallic acid gives a brown precipitate. 5. Hydrosulphuret of potash gives a black precipitate. 6. A plate of iron immersed in these solutions throws down metallic copper, and very rapidly if there be a slight excess of acid. The protoxide of copper can be combined with the acids only by very particular management. All the ordinary salts of copper have the peroxide for a base.

Acetate of copper. The joint agency of air and acetic acid is necessary to the production of the cupreous acetates. By exposing copper plates to the vapours of vinegar, the bluish-green *verdigris* is formed, which by solution in vinegar constitutes acetate of copper. This salt crystallizes in four-sided truncated pyramids. Its colour is a fine bluish-green. Its sp. gr. is 1.78. It has an austere metallic taste; and swallowed, proves a violent poison. Boiling water dissolves one-fifth of the salt, of which it deposits the greater part on cooling. It is soluble also in alcohol. It effloresces by exposure to air. By heat, in a retort, it yields acetic acid, and pyro-acetic spirit. Sulphuretted hydrogen throws down the copper from solutions of this salt, in the state of sulphuret. I had occasion to analyze this salt about two years ago, and found it to consist by experiment of

	Exper.			Theory.
Acetic acid,	52.0	2 atoms	13.26	51.98
Perox. of cop.	39.6	1 do.	10.00	39.20
Water,	8.4	1 do.	2.25	8.82
	100.0		25.51	100.00

More lately, I have prepared a crystallized bin-acetate, which I found to be anhydrous.

Mr. Vauquelin gives for the composition of the crystallized acetate of copper,

Acetic acid .	2 atoms,	12.75	51
Oxide of copper	1	10.00	40
Water . .	3	2.26	9
			100

Verdigris is a mixture of the crystallized acetate of copper and a subacetate. A portion of the latter was extracted by washing pulverized verdigris rapidly, with successive small portions of cold water, to avoid decomposition. This, when dried, was analyzed, for the oxide, by ignition after nitric acid; and for the acid by converting carbonate of potash into acetate. Its constituents were found to be nearly 66.5 oxide, and 33.5 acid. When a solution of crystallized acetate is boiled for some time it is decomposed, a little acetic acid escapes, much black oxide of copper falls down, and when the decomposition ceases, which it always ultimately does, another acetate of copper is found in the solution. This decomposition takes place in close vessels, where no acetic acid is allowed to escape. One hundred parts of the crystallized acetate deposit about 14.63 of oxide, leaving in solution 25.35 parts, combined with twice its weight of acetic acid.

Hence there are three combinations of acetic acid and oxide of copper containing, the first, 66.5 ; the second, 44.44 ; and the third, 33.34 of oxide. If 1 part of verdigris be mixed with 500 of distilled water, and left at a temperature of 60° or 70° F. it gradually becomes yellow, then brown, and in seven or eight days no green portions are to be observed. When filtered, peroxide is obtained ; 100 parts of verdigris were found thus to leave about 23 parts of oxide of copper. It is only the subacetate of the verdigris which undergoes this change. This subacetate is insoluble in water, but decomposable in that fluid into a peroxide and an acetate. The other two salts are the neutral acetate, resolvable by boiling in water into peroxide and superacetate ; and this superacetate. *Memoires de Museum*, x. 295.

The subacetate of Proust, obtained by dissolving verdigris in water, is said to consist of acid and water, 37
Oxide, 63.

The proportion of 40 acid + 60 oxide is that of 1 atom of each, to use the hypothetical term. Now Proust's experiments seem to leave uncertainty to the amount of that difference. This salt should be called probably the *acetate*. Proust's insoluble part of verdigris will become the *subacetate*. This constitutes 44 per cent., and the other 56. But the proportions will fluctuate ; and an intermixture of carbonate may be expected occasionally.

Arseniate of copper presents us with many sub-species which are found native. The arseniate may be formed artificially by digesting arsenic acid on copper, or by adding arseniate of potash to a cupreous saline solution.

1. *Obtuse octohedral arseniate*, consisting of two four-sided pyramids, applied base to base, of a deep sky-blue or grass green colour. Their sp. gr. is 2.88. They consist, according to Chenevix, of 14.3 acid + 50 brown oxide + 35.7 water. 2. *Hexahedral arseniate* is found in fine six-sided laminæ, divisible into thin scales. Its colour is a deep emerald-green ; and its sp. gr. 2.548. It consists, by Vauquelin, of 43 acid + 39 oxide + 18 water. When arseniate of ammonia is poured into nitrate of copper, this variety precipitates in small blue crystals. 3. *Acute octohedral arseniate*, composed of two four-sided pyramids, applied base to base, and sometimes in rhomboidal prisms, with dihedral summits. It consists of 29 acid + 50 oxide + 21 water. The last ingredient is sometimes wanting. 4. *Trihedral arseniate* occurs also in other forms. Colour bluish-green. It consists, by Chenevix, of 30 acid + 54 oxide + 16 water. 5. *Superarseniate.* On evaporating the supernatant solution in the second variety artificially made, and adding alcohol, M. Chenevix obtained a precipitate in small blue rhomboidal crystals. They were composed of 40.1 acid + 35.5 oxide + 24.4 water. The following is a general table of the composition of these arseniates :—

	Acid.	Oxide.	Water.
1.	1.00	3.70	2.50
2.	1.00	2.76	1.00
3.	1.00	1.72	0.70
4.	1.00	1.80	0.53
5.	1.00	0.88	0.60

Arseniate of copper, called Scheele's green, is prepared, by the old prescription of mixing a solution of 2 parts of sulphate of copper in 44 of water, with a solution of 2 parts of potash of commerce, and 1 of pulverized arsenious acid, also in 44 of water. Both solutions being warm, the first is to be gradually poured into the second. The grass-green insoluble precipitate is to be well washed with water.

Carbonate of copper. Of this compound there are three native varieties, the green, the blue, and the anhydrous. According to Mr. R. Philips, the following is the order of their composition :

	1st.	2d.	3d.
Carbonic acid,	2.75	11.00	2.75
Deutox. copper,	10.00	30.00	10.00
Water,	1.125	2.25	0.00
Weights of primes,	13.875	43.25	12.75

The artificial carbonate, obtained by Proust on adding an alkaline carbonate to a solution of the nitrate of copper, is the same with the second kind.

Chlorate of copper is a deflagrating deliquescent green salt.

Fluate of copper is in small blue-coloured crystals.

Hydriodate of copper is a greyish-white powder.

Protomuriate of copper has already been described in treating of the chlorides.

Deutomuriate of copper, formed by dissolving the deutoxide in muriatic acid, or by heating muriatic acid on copper filings, yields by evaporation crystals of a grass-green colour, in the form of rectangular parallelopipeds. Their sp. gr. is 1.68. They are caustic, very deliquescent, and of course very soluble in water. According to Berzelius, it consists of

Acid,	40.2
Deutoxide,	59.8
	100.0.

The *ammonia-nitrate* evaporated, yields a fulminating copper. Crystals of nitrate, mixed with phosphorus, and struck with a hammer, detonate. When pulverized, then slightly moistened, and suddenly wrapt up firm in tin-foil, the nitrate produces an explosive combustion. The nitrate seems to consist of a prime of acid + a prime of deutoxide, besides water of crystallization.

Subnitrate of copper is the blue precipitate, occasioned by adding a little potash to the neutral nitric solution.

Nitrite of copper is formed by mixing nitrite of lead with sulphate of copper.

The *sulphate*, or blue vitriol of commerce, is a bisulphate. Its sp. gr. is 2.2. It consists of

Acid,	31.38	2	primes,	10.0	32.0
Oxide,	32.32	1	do.	10.0	32.0
Water,	36.30	10	do.	11.25	36.0
	100.00			31.25	100.0

A mixed solution of this sulphate and sal ammoniac forms an ink, whose traces are invisible in the cold, but become yellow when heated; and vanish again as the paper cools.

A neutral sulphate of copper may be formed by saturating the excess of acid with oxide of copper. It crystallizes in four-sided pyramids, separated by quadrangular prisms.

M. Proust formed a subsulphate by adding a little pure potash to a solution of the last salt. A green-coloured precipitate falls.

Protosulphite of copper is formed by passing a current of sulphurous acid gas through the deutoxide of copper diffused in water. It is deprived of a part of its oxygen, and combines with the acid. The sulphate, simultaneously produced, dissolves in the water; while the sulphite forms small red crystals, from which merely long ebullition in water expels the acid.

Sulphite of potash and copper is made by adding the sulphite of potash to nitrate of copper. A yellow flocculent precipitate, consisting of minute crystals, falls.

Ammonia-sulphate of copper is the salt formed by adding water of ammonia to solution of the bisulphate. It consists, according to Berzelius, of 1 prime of the cupreous, and 1 of the ammoniacal sulphate, combined together; or 20.0 + 7.13 + 14.625 of water.

Subsulphate of ammonia and copper is formed by adding alcohol to the solution of the preceding salt, which precipitates the subsulphate. It is the *cuprum ammoniacum* of the pharmacopœia. According to Berzelius, it consists of

Acid,	32.23 or nearly	2	primes,
Deutox. of copper,	34.00	1	do.
Ammonia,	26.40	4	do.
Water,	7.35	2	do.
	100.00		

Sulphate of potash and copper is formed by digesting bisulphate of potash on the deutoxide or carbonate of copper. Its crystals are greenish-coloured, flat parallelopipedons. It seems to consist of 2 primes of sulphate of potash + 1 prime of bisulphate of copper + 12 of water.

The following acids, antimonic, antimonious, boracic, chromic, molybdic, phosphoric, tungstic, form insoluble salts with deutoxide of copper. The first two are green, the third is brown, the fourth and fifth green, and the sixth white. The benzoate is in green crystals, sparingly soluble. The oxalate is also green. The binoxalates of potash and soda, with oxide of copper, give triple salts, in green needle-form crystals. There are also ammonia-oxalates in different varieties. Tartrate of copper forms dark bluish-green crystals. Cream-tartrate of copper is a bluish-green powder, commonly called Brunswick green. M. Vuaflart has observed that chromate of copper, prepared by precipitating sulphate of copper by chromate of potash, and which is of a reddish-brown colour, is soluble in dilute water of ammonia, producing a clear solution of a beautiful and deep green colour. When the solution is evaporated, the reddish chromate of copper appears as the ammonia flies off. The readiest way of preparing this permanent and beautiful colour, is to add solution of chromate of potash to ammoniacal sulphate of copper. *Journ. de Pharmacie* for 1824, p. 607. See Salt.

To obtain pure copper for experiments, we precipitate it in the metallic state, by immersing a plate of iron in a solution of the deutomuriate. The pulverulent copper must be washed with dilute muriatic acid.

In the wet way, Brunswick or Friezland green is prepared by pouring a saturated solution of muriate of ammonia over copper filings or shreds in a close vessel, keeping the mixture in a warm place, and adding more of the solution from time to time, till three parts of muriate and two of copper have been used. After standing a few weeks, the pigment is to be separated from the unoxidised copper, by washing through a sieve; and then it is to be well washed, and dried slowly in the shade. This green is almost always adulterated with ceruse.

This metal combines very readily with gold, silver, and mercury. It unites imperfectly with iron in the way of fusion. Tin combines with copper, at a temperature much lower than is necessary to fuse the copper alone. On this is grounded the method of tinning copper vessels. For this purpose, they are first scraped or scoured; after which they are rubbed with sal ammoniac. They are then heated, and sprinkled with powdered resin, which defends the clean surface of the copper from acquiring the slight film of oxide that would prevent the adhesion of the tin to its surface. The melted tin is then poured in, and spread about. An extremely small quantity adheres to the copper, which may perhaps be supposed insufficient to prevent the noxious effects of the copper as perfectly as might be wished.

When tin is melted with copper, it composes the compound called bronze. In this metal the specific gravity is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. The uses of this hard, sonorous, and durable composition, in the fabrication of cannon, bells, statues, and other articles, are well known. Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher is more particularly directed to the mixture of copper and tin, on account of its being the substance of which the speculums of reflecting telescopes are made. See SPECULUM. The ancients made cutting instruments of this alloy. A dagger analyzed by Mr. Hielm consisted of 83⅞ copper, and 16⅛ tin.

Copper unites with bismuth, and forms a reddish-white alloy. With arsenic it forms a white brittle compound, called tombac. With zinc it forms the compound called brass, and distinguished by various other names, according to the proportions of the two ingredients. It is not easy to unite these two metals in considerable proportions by fusion, because the zinc is burnt or volatilized at a heat inferior to that which is required to melt copper; but they unite very well in the way of cementation. In the brass works, copper is granulated by pouring it through a plate of iron, perforated with small holes and luted with clay, into a quantity of water about four feet deep, and continually renewed: to prevent the dangerous explosions of this metal, it is necessary to pour but a small quantity at a time. There are various methods of combining this granulated copper, or other small pieces of copper, with the vapour of zinc. Calamine, which is an ore of zinc, is pounded, calcined, and mixed with the divided copper, together with a portion of charcoal. These being exposed to the heat of a wind furnace, the zinc becomes revived, rises in vapour, and combines with the copper, which it converts into brass. The heat must be continued for a greater or less number of hours, according to the thickness of the pieces of copper, and other circumstances; and at the end of the process, the heat being suddenly raised, causes the brass to melt, and occupy the lower part of the crucible. The most scientific method of making brass seems to be that mentioned by Cramer. The powdered calamine, being mixed with an equal quantity of charcoal and a portion of clay, is to be rammed into a melting vessel, and a quantity of copper, amounting to two-thirds of the weight of calamine, must be placed on the top, and covered with charcoal. By this management the volatile zinc ascends, and converts the copper into brass, which flows into the rammed clay; consequently, if the calamine contain lead, or any other metal, it will not enter into brass, the zinc alone being raised by the heat.

A fine kind of brass, which is supposed to be made by cementation of copper plates with calamine, is hammered out into leaves in Germany; and is sold very cheap in this country, under the name of Dutch gold or Dutch metal. It is about five times as thick as gold leaf; that is to say, it is about one sixty-thousandth of an inch thick.

Copper unites readily with antimony, and affords a compound of a beautiful violet colour. It does not readily unite with manganese. With tungsten it forms a dark brown spongy alloy, which is somewhat ductile. See ORES OF COPPER.

Verdigris, and other preparations of copper, act as virulent poisons, when introduced in very small quantities into the stomachs of animals. A few grains are sufficient for this effect. Death is commonly preceded by very decided nervous disorders, such as convulsive movements, tetanus, general insensibility, or a palsy of the lower extremities. This event happens frequently so soon, that it could not be occasioned by inflammation or erosion of the *primæ viæ;* and indeed, where these parts are apparently sound, it is probable that the poison is absorbed, and, through the circulation, acts on the brain and nerves. The cupreous preparations are no doubt very acrid, and if death do not follow their immediate impression on the sentient system, they will certainly inflame the intestinal canal. The symptoms produced by a dangerous dose of copper are exactly similar to those which are enumerated under arsenic, only the taste of copper is strongly felt. The only chemical antidote to cupreous solutions, whose operation is well understood, is water strongly impregnated with sulphuretted hydrogen. The alkaline hydrosulphurets are acrid, and ought not to be prescribed.

But we possess, in sugar, an antidote to this poison, of undoubted efficacy, though its mode of action be obscure. M. Duval introduced into the stomach of a dog, by means of a caoutchouc tube, a solution in acetic acid, of four French drachms of oxide of copper. Some minutes afterwards, he injected into it four ounces of strong syrup. He repeated this injection every half-hour, and employed altogether 12 ounces of syrup. The animal experienced some tremblings and convulsive movements. But the last injection was followed by a perfect calm. The animal fell asleep, and awakened free from any ailment.

Orfila relates several cases of individuals who had by accident or intention swallowed poisonous doses of acetate of copper, and who recovered by getting large doses of sugar. He uniformly found, that a dose of verdigris, which would kill a dog in the course of an hour or two, might be swallowed with impunity, provided it was mixed with a considerable quantity of sugar.

If we boil for half an hour, in a flask, an ounce of white sugar, an ounce of water, and 10 grains of verdigris, we obtain a green liquid, which is not affected by the nicest tests of copper, such as ferroprussiate of potash, ammonia, and the hydrosulphurets. An insoluble green carbonate of copper remains at the bottom of the flask. Vogel states, that sugar boiled with sulphate of copper precipitates metallic copper; and with acetate, protoxide.

COPPERAS. Sulphate of iron.

CORALS seem to consist of carbonate of lime and animal matter, in equal proportions.

CORK is the bark of a tree of the oak kind, very common in Spain and the other southern parts of Europe.

By the action of the nitric acid it was found to be acidified. See ACID (SUBERIC).

Cork has been recently analyzed by Chevreul by digestion, first in water and then in alcohol. By distillation there came over an aromatic principle, and a little acetic acid. The watery extract contained a yellow and a red colouring matter, an undetermined acid, gallic acid, an astringent substance, a substance containing azote, a substance soluble in water and insoluble in alcohol, gallate of iron, lime, and traces of magnesia. 20 parts of cork treated in this way left 17.15 of insoluble matter. The undissolved residue being treated a sufficient number of times with alcohol, *yielded* a variety of bodies, but which seem reducible to three; namely, *cerin*, resin, and an oil. The ligneous portion of the cork still weighed 14 parts, which are called *suber*.

CORK (FOSSIL). See ASBESTOS.

CORROSIVE SUBLIMATE. See MERCURY.

CORUNDUM. According to Professor Jameson, this mineral genus contains 3 species, viz. *octohedral* corundum, *rhomboidal* corundum, and *prismatic* corundum.

1. *Octohedral* is subdivided into 3 subspecies, viz. automalite, ceylanite, and spinel.

2. *Rhomboidal* corundum contains 4 subspecies, viz. salamstone, sapphire, emery, and corundum, or adamantine spar.

3. *Prismatic*, or chrysoberyl. See the several sub-species, under their titles in the Dictionary.

COTTON. This vegetable fibre is soluble in strong alkaline leys. It has a strong affinity for some earths, particularly alumina, several metallic oxides, and tannin. Nitric acid, aided by heat, converts cotton into oxalic acid.

My analysis gives for the ultimate constituents of cotton, carbon, 42.11; hydrogen, 5.06; oxygen, 52.83; or nearly

Carbon	11 atoms	8·25	42·85
Hydrogen	8	1.00	5.20
Oxygen	10	10·00	51.85
		19.25	100.00

2000 grains of clean cotton wool, in the soft fleece, formed by the cylinder cards, being carefully burned in a silver basin, yielded on an average of 6 trials, 19 grains of light grey ashes, which is a trifle under 1 per cent. One hundred parts of the ashes of cotton seem, by my researches, to be composed of

1. Soluble matter.

Carbonate of potash	44.8
Muriate of potash	9·9
Sulphate of potash	9·3

2. Insoluble matter.

Phosphate of lime	9·0
Carbonate of lime	10·6
Phosphate of magnesia	8.4
Peroxide of iron	3.0
Alumina (a trace)	
Loss	5.0
	100.0

Journ. of Science, xxi. 28.

COUCH. The heap of moist barley about 16 inches deep on the malt-floor.

COUZERANITE. This mineral occurs in rectangular prisms. Colour from greyish black to indigo blue. Opaque, but in thin portions transparent and brilliant. Scratched by apatite. Not affected by the blowpipe. It is found in limestone, in the steep defiles of Saleix, called "des Couserans."

CREAM. The oily part of milk, which rises to the surface of that liquid, mixed with a little curd and *serum*. When churned, butter is obtained. Heat separates the oily part, but injures its flavour.

CREAM OF TARTAR. See ACID (TARTARIC).

CRICHTONITE. This mineral occurs in very small crystals, in the form of acute rhomboids. It is perfectly black, opaque, and of a shining lustre; cross fracture, conchoidal, and very shining. It scratches fluate of lime, but is not very hard. It occurs accompanying anatase, and on rock crystal in Dauphiny.

CROCUS (SAFFRON). The yellow or saffron-coloured oxides of iron and copper were formerly called crocus martis and crocus veneris. That of iron is still called crocus simply, by the workers in metal who use it.

CROCUS METALLORUM. See ANTIMONY.

CROSS-STONE. Harmotome, or pyramidal zeolite. Its colour is greyish-white, passing into smoke-grey, sometimes massive, but usually crystallized. Primitive form, a double four-sided pyramid, of 121° 58′ and 86° 36′. Its principal secondary forms are, a broad rectangular four-sided prism, rather acutely acuminated on the extremities with 4 planes, which are set on the lateral edges; the preceding figure, in which the edges formed by the meeting of the acuminating planes, that rest on the broader lateral planes, are truncated; twin crystals of the first form, intersecting each other, in such a manner that a common axis and acumination is formed, and the broader lateral planes make four re-entering angles. The crystals are not large. The surface of the smaller lateral planes is double-plumosely streaked. Lustre glistening, between vitreous and pearly. Of the cleavage, 2 folia are oblique, and 1 parallel to the axis. Fracture perfect conchoidal. Translucent and semitransparent. Harder than fluor spar, but not so hard as apatite. Easily frangible. Sp. gr. 2.35. It fuses with intumescence and phosphorescence, into a colourless glass. Its constituents are 49 silica, 16 alumina, 18 barytes, and 15 water, by Klaproth. It has hitherto been found only in mineral veins and agate balls. It occurs at Andreasburg, in the Hartz; at Kongsberg, in Norway; at Oberstein; Strontian, in Argyllshire; and also near Old Kilpatrick, in Scotland. *Jameson.*

CRASSAMENTUM, or CRUOR. The clot, or coagulated part of blood.

CROTON ELEUTHERIA. Cascarilla bark. The following is Trommsdorf's analysis of this substance, characterized by its emitting the smell of musk when burned. Mucilage and bitter principle 864 parts, resin 688, volatile matter 72, water 48, woody fibres 3024; in 4696 parts.

CRUCIBLES. See LABORATORY.

CRUSTS, the bony coverings of crabs, lobsters, &c. Mr. Hatchett found them to be composed of a cartilaginous substance, like coagulated albumen, carbonate of lime, and phosphate of lime. The great excess of the second above the third ingredient distinguishes them from bones; while the quantity of the third distinguishes them from shells. Egg-shells and snail shells belong to crusts in composition; but the animal matter is in smaller quantity. By Merat-Guillot, 100 parts of lobster crust consist of 60 carbonate of lime, 14 phosphate of lime, and 26 cartilaginous matter. 100 of hen's egg-shells consist of 89.6 carbonate of lime, 5.7 phosphate of lime, 4.7 animal matter.

CRYOLITE. A mineral which occurs massive, disseminated, and in thick lamellar concretions. Its colours are white and yellowish-brown. Lustre vitreous, inclining to pearly. Cleavage fourfold, in which the folia are parallel with an equiangular four-sided pyramid. Fracture uneven. Translucent. Harder than gypsum. Easily frangible. Sp. gr. 2.95. It becomes more translucent in water. It melts in the heat of a candle. Before the blowpipe, it becomes first very liquid, and then assumes a slaggy appearance. It consists, by Klaproth, of 24 alumina, 36 soda, and 40 fluoric acid and water. It is therefore a soda-fluate of alumina. If we regard it as composed of definite proportions, we may have

1 prime	alumina,	3·2	26·33	
1 do.	soda,	3·95	32·51	
2 do.	acid,	2·75	22·63	41·16
2 do.	water,	2·25	18·53	
		12·15	100·00	

Vauquelin's analysis of the same mineral gives 47 acid and water, 32 soda, and 21 alumina. This curious and rare mineral has hitherto been found only in West Greenland, at the arm of the sea named Arksut, 30 leagues from the colony of Juliana Hope. It occurs in gneiss. Mr. Allan of Edinburgh had the merit of recognizing a large quantity of this mineral, in a neglected heap brought into Leith from a captured Danish vessel. It had been collected in Greenland by that indefatigable mineralogist M. Gieseke.

CRYOPHORUS. The frost-bearer or carrier of cold, an elegant instrument invented by Dr. Wollaston, to demonstrate the relation between evaporation at low temperatures, and the production of cold. If 32 grains of water, says this profound philosopher, were taken at the temperature of 62°, and if one grain of this were converted into vapour by absorbing 960°, then the whole quantity would lose $\frac{960°}{32} = 30°$, and thus be reduced to the temperature of 32°. If from the 31 grains which still remain in the state of water, four grains more were converted into vapour by absorbing 960°, then the remaining 27 grains must have lost $\frac{4}{27}$ of 960° = 142°, which is rather more than sufficient to convert the whole into ice. In an experiment conducted upon a small scale, the proportional quantity evaporated did not differ much from this estimate.

If it be also true that water, in assuming the gaseous state, even at a low temperature, expands to 1800 times its former bulk, then in attempting to freeze the small quantity of water above mentioned, it would be requisite to have a dry vacuum with the capacity of 5 × 1800 = 9000 grains of water. But let a glass tube be taken, having its internal diameter about $\frac{1}{8}$ of an inch, with a ball at each extremity of about one inch diameter, and let the tube be bent to a right angle at the distance of half an inch from each ball. One of these balls should be somewhat less than half full of water, and the remaining cavity should be as perfect a vacuum as can readily be obtained; which is effected by making the water boil briskly in the one ball, before sealing up the capillary opening left in the other. If the empty ball be immersed in a freezing mixture of snow and salt, the water in the other ball, though at the distance of two or three feet, will be frozen solid in the course of a very few minutes. The vapour contained in the empty ball is condensed by the common operation of cold, and the vacuum produced by this condensation gives opportunity for a fresh quantity to arise from the opposite ball, with proportional reduction of its temperature.

CRYSTAL. When fluid substances are suffered to pass with adequate slowness to the solid state, the attractive forces frequently arrange their ultimate particles so as to form regular polyhedral figures or geometrical solids, to which the name of crystals has been given. Most of the solids which compose the mineral crust of the earth are found in the crystallized state. Thus granite consists of crystals of quartz, felspar, and mica. Even mountain masses like clay-slate have a regular tabulated form. Perfect mobility among the corpuscles is essential to crystallization. The chemist produces it either by igneous fusion, or by solution in a liquid. When the temperature is slowly lowered in the former case, or the liquid slowly abstracted by evaporation in the latter, the attractive forces resume the ascendency, and arrange the particles in symmetrical forms. Mere approximation of the particles, however, is not alone sufficient for crystallization. A hot saturated saline solution, when screened from all agitation, will contract by cooling into a volume much smaller that what it occupies in the solid state, without crystallizing. Hence the molecules must not only be brought within a certain limit of each other, for their concreting into crystals; but they must also change the direction of their poles from the fluid collocation to their position in the solid state.

This reversion of the poles may be effected, 1st, By contact of any part of the fluid with a point of a solid, of similar composition, previously formed. 2d, Vibratory motions communicated, either from the atmosphere or any other moving body, by deranging, however slightly, the fluid polar direction, will instantly determine the solid polar arrangement, when the balance had been rendered nearly even by previous removal of the interstitial fluid. On this principle we explain the regular figures which particles of dust or iron assume, when they are placed on a vibrating plane, in the neighbourhood of electrized or magnetized bodies. 3d. Negative or resinous voltaic electricity instantly determines the crystalline arrangement, while positive voltaic electricity counteracts it. On this subject I beg to refer the reader to an experimental paper which I published in the fourth volume of the Journal of Science, p. 106. Light also favours crystallization, as is exemplified with camphor dissolved in spirits, which crystallizes in bright and redissolves in gloomy weather.

It might be imagined, that the same body would always concrete in the same, or at least in a similar crystalline form. This position is true, in general, for the salts crystallized in the laboratory; and on this uniformity of figure, one of the principal criteria between different salts depends. But even these forms are liable to many modifications, from causes apparently slight; and in nature, we find frequently the same chemical substance crystallized in forms apparently very dissimilar. Thus, carbonate of lime assumes the form of a rhomboid, of a regular hexahedral prism, of a solid terminated by 12 scalene angles, or of a dodecahedron with pentagonal faces, &c. Bisulphuret of iron or martial pyrites produces sometimes cubes and sometimes regular octohedrons, at one time dodecahedrons with pentagonal faces, at another icosahedrons with triangular faces, &c.

While one and the same substance lends itself to so many transformations, we meet with very different substances, which present absolutely the same form. Thus fluate of lime, muriate of soda, sulphuret of iron, sulphuret of lead, &c. crystallize in cubes, under certain circumstances; and in other cases, the same minerals, as well as sulphate of alumina and the diamond, assume the form of a regular octohedron.

Romé de l'Isle first referred the study of crystallization to principles conformable to observation. He arranged together, as far as possible, crystals of the same nature. Among the different forms relative to each species, he chose one as the most proper, from its simplicity, to be regarded as the primitive form; and by supposing it truncated in different ways, he deduced the other forms from it, and determined a gradation, a series of transitions between this same form and that of polyhedrons, which seemed to be still farther removed from it. To the descriptions and figures which he gave of the crystalline forms, he added the results of the mechanical measurement of their principal angles, and showed that these angles were constant in each variety.

The illustrious Bergmann, by endeavouring to penetrate to the mechanism of the structure of crystals, considered the different forms relative to one and the same substance as produced by a superposition of planes, sometimes constant and sometimes variable, and decreasing around one and the same primitive form. He applied this primary idea to a small number of crystalline forms, and verified it with respect to a variety of calcareous spar[†] by fractures, which enabled him to ascertain the position of the nucleus, or of the primitive form, and the successive order of the laminæ covering this nucleus. Bergmann, however, stopped here, and did not trouble himself either with determining the laws of structure, or applying calculation to it. It was a simple sketch of the most prominent point of view in mineralogy, but in which we see the hand of the same master who so successfully filled up the outlines of chemistry.

In the researches which M. Haüy undertook, about the same period, on the structure of crystals, he proposed combining the form and dimensions of integrant molecules with simple and regular laws of arrangement, and submitting these laws to calculation. This work produced a mathematical theory, which he reduced to analytical formulæ, representing every possible case, and the application of which to known forms leads to valuations of angles, constantly agreeing with observation.

[†] This is what has been called *dent de cochon*, but which M. Haüy calls *metastatic*.

Theory of the Structure of Crystals.

Primitive forms.—The idea of referring to one of the same primitive forms, all the forms which may be assumed by a mineral substance, of which the rest may be regarded as being modifications only, has frequently suggested itself to various philosophers, who have made crystallography their study.

The mechanical division of minerals, which is the only method of ascertaining their true primitive form, proves that this form is invariable while we operate upon the same substance, however diversified or dissimilar the forms of the crystals belonging to this substance may be. Two or three examples will serve to place this truth in its proper light.

Take a regular hexahedral prism of carbonate of lime (Pl. viii. figs. 1. and 2). If we try to divide it parallel to the edges, from the contours of the bases, we shall find, that three of these edges taken alternately in the upper part, for instance, the edges $l\,f$, $c\,d$, $b\,m$, may be referred to this division: and in order to succeed in the same way with respect to the inferior base, we must choose not the edges, $l'\,f'$, $c'\,d'$, $b'\,m'$, which correspond with the preceding, but the intermediate edges $d'\,f'$, $b'\,c'$, $l'\,m'$.

The six sections will uncover an equal number of trapeziums. Three of the latter are represented upon fig. 2. viz. the two which intercept the edges, $l\,f$, $c\,d$, and are designated by $p\,p\,o\,o$, $a\,a\,k\,k$, and that which intercepts the lower edge $d'\,f'$, and which is marked by the letters $n\,n\,i\,i$.

Each of these trapeziums will have a lustre and polish, from which we may easily ascertain, that it coincides with one of the natural joints of which the prism is the assemblage. We shall attempt in vain to divide the prism in any other direction. But if we continue the division parallel to the first sections, it will happen, that on one hand the surfaces of the bases will always become narrower, while, on the other hand, the altitudes of the lateral planes will decrease; and at the term at which the bases have disappeared, the prism will be changed into a dodecahedron (fig. 3.) with pentagonal faces, six of which, such as $o\,o\,i\,O\,e$, $o\,I\,k\,i\,i$, &c. will be the residues of the planes of the prism; and the six others $E\,A\,I\,o\,o$, $O\,A'\,K\,i\,i$, &c. will be the immediate result of the mechanical division.

Beyond this same term, the extreme faces will preserve their figure and dimensions, while the lateral faces will incessantly diminish in height, until the points o, k, of the pentagon $o\,I\,k\,i\,i$, coming to be confounded with the points $i\,i$; and so on with the other points similarly situated, each pentagon will be reduced to a simple triangle, as we see in fig. 4.[*]

Lastly, when new sections have obliterated these triangles, so that no vestige of the surface of the prism remains (fig. 1), we shall have the nucleus or the primitive form, which will be an obtuse rhomboid (fig. 5.), the grand angle of which E A I or E O I, is 101° 32′ 13″[†].

If we try to divide a crystal of another species, we shall have a different nucleus. For instance, a cube of fluate of lime will give a regular octohedron, which we succeed in extracting by dividing the cube upon its eight solid angles, which will in the first place discover eight equilateral triangles, and we may pursue the division, always parallel to the first sections, until nothing more remains of the faces of the cube. The nucleus of the crystals of sulphate of barytes will be a straight prism with rhombous bases; that of the crystals of phosphate of lime, a regular hexahedral prism; that of sulphuretted lead, a cube, &c.; and each of these forms will be constant, relative to the entire species, in such a manner, that its angles will not undergo any appreciable variation.

Having adopted the word *primitive form* in order to designate the nucleus of crystals, M. Haüy calls *secondary forms*, such varieties as differ from the primitive form.

In certain species, crystallization also produces this last form immediately.

We may define the primitive form, a solid of a constant form, engaged symmetrically in all the crystals of one and the same species, and the faces of which follow the directions of the laminæ which form these crystals.

The primitive forms hitherto observed are reduced to six, viz. the parallelopipedon, the octohedron, the tetrahedron, the regular hexahedral prism, the dodecahedron with rhombous planes all equal and similar, and the dodecahedron with triangular planes, composed of two straight pyramids joined base to base.

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[*] The points which are confounded, two and two, upon this figure, are each marked with the two letters which served to designate them when they were separated, as in fig. 3.

[†] It is observed, that each trapezium, such as $p\,p\,o\,o$ (fig. 2.), uncovered by the first sections, is very sensibly inclined from the same quantity, as well upon the residue $p\,p\,d\,e\,b\,m$ of the base, as upon the residue $o\,o\,f'\,l'$ of the adjacent plane. Setting out from this equality of inclinations, we deduce from it by calculation, the value of the angles with the precision of minutes and seconds, which mechanical measurements are not capable of attaining.

Forms of integrant Molecules.—The nucleus of a crystal is not the last term of its mechanical division. It may always be subdivided parallel to its different faces, and sometimes in other directions also. The whole of the surrounding substance is capable of being divided by strokes parallel to those which take place with respect to the primitive form.

If the nucleus be a parallelopipedon, which cannot be subdivided except by blows parallel to its faces, like that which takes place with respect to carbonated lime, it is evident that the integrant molecule will be similar to this nucleus itself.

But it may happen that the parallelopipedon admits of further sections in other directions than the former.

We may reduce the forms of the integrant molecules of all crystals to three, which are, the tetrahedon, or the simplest of the pyramids; the triangular prism, or the simplest of all the prisms; and the parallelopipedon, or the simplest among the solids, which have their faces parallel two and two. And since four planes at least are necessary for circumscribing a space, it is evident that the three forms in question, in which the number of faces is successively four, five, and six, have still, in this respect, the greatest possible simplicity.

Laws to which the Structure is subjected.—After having determined the primitive forms, and those of the integrant molecules, it remains to inquire into the laws pursued by these molecules in their arrangement, in order to produce those regular kinds of envelopes, which disguise one and the same primitive form in so many different ways.

Now, observation shows, that this surrounding matter is an assemblage of laminæ, which, setting out from the primitive form, decrease in extent, both on all sides at once, and sometimes in certain particular parts only. This decrement is effected by regular subtractions of one or more rows of integrant molecules; and the theory, in determining the number of these rows by means of calculation, succeeds in representing all the known results of crystallization, and even anticipates future discoveries, indicating forms which, being still hypothetical only, may one day be presented to the inquiries of the philosopher.

Decrements on the Edges.—Let *s s'* (fig. 6. pl. viii.) be a dodecahedron with rhombic planes. This solid, which is one of the six primitive forms of crystals, also presents itself occasionally as a secondary form, and in this case it has, as a nucleus, sometimes a cube and sometimes an octohedron. Supposing the nucleus to be a cube:—

In order to extract this nucleus, it is sufficient successively to remove the six solid angles composed of four planes, such as *s*, *r*, *t*, &c. by sections adapted to the direction of the small diagonals. These sections will display as many squares A E O I, E O O' E', I O O' I' (fig. 7.), &c. which will be the faces of the cube.

Let us conceive that each of these faces is subjected to a series of decreasing laminæ solely composed of cubic molecules, and that every one of these laminæ exceeds the succeeding one, towards its four edges, by a quantity equal to one course of these same molecules. Afterwards we shall designate the decreasing laminæ which envelope the nucleus, by the name of *laminæ of superposition.* Now, it is easy to conceive that the different series will produce six quadrangular pyramids, similar in some respects to the quadrangular steps of a column, which will rest on the faces of the cube. Three of these pyramids are represented in fig. 8. and have their summits in *s*, *t*, *r'*.

Now, as there are six quadrangular pyramids, we shall therefore have twenty-four triangles, such as, O *s* I, O *t* I, &c. But because the decrement is uniform from *s* to *t*, and so on with the rest; the triangles taken two and two are on a level, and form a rhomb *s* O *t* I. The surface of the solid will therefore be composed of twelve equal and similar rhombs; *i. e.* this solid will have the same form with that which is the subject of the problem. This structure takes place, although imperfectly, with respect to the crystals called *boracic spars.*

The dodecahedron now under consideration is represented by fig. 8. in such a way that the progress of the decrement may be perceived by the eye. On examining the figure attentively, we shall find that it has been traced on the supposition, that the cubic nucleus has on each of its edges 17 ridges of molecules; whence it follows, that each of its faces is composed of 289 facets of molecules, and that the whole solid is equal to 4913 molecules. On this hypothesis, there are eight laminæ of superposition, the last of which is reduced to a simple cube, whose edges determine the numbers of molecules which form the series 15, 13, 11, 9, 7, 5, 3, 1, the difference being 2, because there is one course subtracted from each extremity.

Now, if instead of this coarse kind of masonry, which has the advantage of speaking to the eye, we substitute in our imagination the infinitely delicate architecture of nature, we must conceive the nucleus as being composed of an incomparably greater number of imperceptible cubes. In this case, the number of laminæ of superposition will also be beyond comparison greater than on the preceding hypothesis. By a necessary consequence, the furrows which form these laminæ by the alternate projecting and re-entering of their edges, will not be cognizable by our courses; and this is what takes place in the polyhedra which crystallization has produced at leisure, without being disturbed in its progress.

M. Haüy calls *decrements in breadth*, those in which each lamina has only the height of a molecule; so that their whole effect, by one two, three, &c. courses, is in the way of breadth. *Decrements in height* are those in which each lamina, exceeding only the following one by a single course in the direction of the breadth, may have a height double, triple, quadruple, &c. to that of a molecule: this is expressed by saying that the decrement takes place by two courses, three courses, &c. in height.

The light which the theory of definite proportions has thrown upon chemistry, the mechanical views by which the atomic philosophy accounts for fixed proportions, the use which has been made of these views to represent bodies composed of a determinate number of atoms, engaged M. Mitscherlich to examine the following problems: Different elements being combined with the same number of atoms of one element, or of several different elements, have they the same crystalline *form*? Is the identity of the crystalline form determined only by the *number* of atoms? Is this form independent of the chemical nature of the elements.

The trials which he has made, appear to him to demonstrate that certain different elements, combined with the same number of one or of several elements, affect the same crystalline form; and that chemical elements in general may in this respect be classed in groups. He gives the epithet *isomorphous* to those elements which belong to the same group, in order to express this quality of the elements by a technical term. Thus, every arseniate, he says, has a phosphate, which corresponds to it, composed according to the same proportions, combined with the same atoms of water of crystallization, and which at the same time has the same physical qualities. In a word, the two series of salts with the phosphorous and phosphoric, arsenious and arsenic acids, differ in no respect, except that the radical of the acid of one series is phosphorus, and of the other is arsenic.

The conclusion at which he arrives, is: The same number of atoms combined in the same manner produces the same crystalline form; and the same crystalline form is independent of the chemical nature of the atoms, being determined only by their number and relative position. *Ann. de Chim. et Phys.* xix. 350.

Mr. Brooke, after urging several strong objections against the theory advanced by M. Mitscherlich, says, that he is informed the author has lately abandoned it, which however there is good reason to doubt.

We are indebted to Dr. Wollaston for ideas on the *ultimate* cause of crystalline forms, equally ingenious and profound. They were communicated to the Royal Society, and published in their transactions for the year 1813.

Among the known forms of crystallized bodies, there is no one common to a greater number of substances than the regular octohedron, and no one in which a corresponding difficulty has occurred with regard to determining which modification of its form is to be considered as primitive; since in all these substances the tetrahedron appears to have equal claim to be received as the original from which all their other modifications are to be derived.

The relation of these solids to each other is most distinctly exhibited to those who are not much conversant with crystallography, by assuming the tetrahedron as primitive, for this may immediately be converted into an octohedron by the removal of four smaller tetrahedrons from its solid angles. Plate ix. fig. 1.

The substance which most readily admits of division by fracture into these forms, is fluor spar; and there is no difficulty in obtaining a sufficient quantity for such experiments. But it is not, in fact, either the tetrahedron or the octohedron, which first presents itself as the apparent primitive form obtained by fracture.

If we form a plate of uniform thickness by two successive divisions of the spar, parallel to each other, we shall find the plate divisible into prismatic rods, the section of which is a rhomb of 70° 32′ and 109° 28′ nearly: and if we again split these rods transversely, we shall obtain a number of regular acute rhomboids, all similar to each other, having their superficial angles 60° and 120°, and presenting an appearance of primitive molecules, from which all the other modifications of such crystals might very simply be derived. And we find, moreover, that the whole mass of fluor might be divided into, and conceived to consist of, these acute rhomboids alone, which may be put together so as to fit each other without any intervening vacuity.

But, since the solid thus obtained (as represented fig. 2.) may be again split by natural fractures at right angles to its axis (fig. 3), so that a regular tetrahedron may be detached from each extremity, while the remaining portion assumes the form of a regular octohedron; and since every rhomboid that can be obtained must admit of the same division into one octohedron and two tetrahedrons, the rhomboid can no longer be regarded as the primitive form; and since the parts into which it is divisible are dissimilar, we are left in doubt which of them is to have precedence as primitive.

In the examination of this question, whether we adopt the octohedron or the tetrahedron as the primitive form, since neither of them can fill space without leaving vacuities, there is a difficulty in conceiving any arrangement in which the particles will remain at rest: for, whether we suppose, with the Abbé Haüy, that the particles are tetrahedral with octohedral cavities, or, on the contrary, octohedral particles regularly arranged with tetrahedral cavities, in each case the mutual contact of adjacent particles is only at their edges; and although in such an arrangement it must be admitted that there may be an equilibrium, it is evidently unstable, and ill adapted to form the basis of any permanent crystal.

With respect to fluor spar, and such other substances as assume the octohedral and tetrahedral forms, all difficulty is removed, says Dr. Wollaston, by supposing the elementary particles to be perfect spheres, which, by mutual attraction, have assumed that arrangement which brings them as near to each other as possible.

The relative position of any number of equal balls in the same plane, when gently pressed together, forming equilateral triangles with each other (as represented perspectively in fig. 4.), is familiar to every one; and it is evident that, if balls so placed were cemented together, and the stratum thus formed were afterwards broken, the straight lines in which they would be disposed to separate would form angles of 60° with each other.

If a single ball were placed any where at rest upon the preceding stratum, it is evident that it would be in contact with three of the lower balls (as in fig. 5.), and that the lines joining the centres of four balls so in contact, or the planes touching their surfaces, would include a regular tetrahedron, having all its equilateral triangles.

The construction of an octohedron, by means of spheres alone, is as simple as that of the tetrahedron. For, if four balls be placed in contact on the same plane, in form of a square, then a single ball resting upon them in the centre, being in contact with each pair of balls, will present a triangular face rising from each side of the square, and the whole together will represent the superior apex of an octohedron; so that a sixth ball similarly placed underneath the square will complete the octohedral group, fig. 6.

There is one observation with regard to these forms that will appear paradoxical, namely, that a structure, which in this case was begun upon a square foundation, is really intrinsically the same as that which is begun upon the triangular basis. But if we lay the octohedral group, which consists of six balls, on one of its triangular sides, and, consequently, with an opposite triangular face uppermost, the two groups, consisting of three balls each, are then situated precisely as they would be found in two adjacent strata of the triangular arrangement. Hence, in this position, we may readily convert the octohedron into a regular tetrahedron, by addition of four more balls (fig 7.). One placed on the top of the three that are uppermost forms the apex; and if the triangular base, on which it rests, be enlarged by addition of three more balls, regularly disposed around it, the entire group of ten balls will then be found to represent a regular tetrahedron.

For the purpose of representing the acute rhomboid, two balls must be applied at opposite sides of the smallest octohedral group, as in fig. 9. And if a greater number of balls be placed together, fig. 10. and 11. in the same form, then a complete tetrahedral group may be removed from each extremity, leaving a central octohedron, as may be seen in fig. 11. which corresponds to fig. 3.

We have seen, that, by due application of spheres to each other, all the most simple forms of one species of crystal will be produced, and it is needless to pursue any other modifications of the same form, which must result from a series of decrements produced according to known laws.

Since then the simplest arrangement of the most simple solid that can be imagined affords so complete a solution of one of the most difficult questions in crystallography, we are naturally led to inquire what forms would probably occur from the union of other solids most nearly allied to the sphere. And it will appear, that by the supposition of elementary particles that are spheroidical, we may frame conjectures as to the origin of other angular solids well known to crystallographers.

The obtuse Rhomboid.

If we suppose the axis of our elementary spheroid to be its shortest dimension, a class of solids will be formed which are numerous in crystallography. It has been remarked above, that by the natural grouping of spherical particles, fig. 10. one resulting solid is an acute rhomboid, similar to that of fig. 2. having certain determinate angles, and its greatest dimension in the direction of its axis. Now, if other particles having the same relative arrangement be supposed to have the form of oblate spheroids, the resulting solid, fig. 12. will still be a regular rhomboid; but the measures of its angles will be different from those of the former, and will be more or less obtuse according to the degree of oblateness of the primitive spheroid.

It is at least possible that carbonate of lime and other substances, of which the forms are derived from regular rhomboids as their primitive form, may, in fact, consist of oblate spheroids as elementary particles.

Hexagonal Prisms.

If our elementary spheroid be on the contrary oblong, instead of oblate, it is evident that, by mutual attraction, their centres will approach nearest to each other when their axes are parallel, and their shortest diameters in the same plane (fig. 13). The manifest consequence of this structure would be, that a solid so formed would be liable to split into plates at right angles to the axes, and the plates would divide into prisms of three or six sides with all their angles equal, as occurs in phosphate of lime, beryl, &c.

It may farther be observed, that the proportion of the height to the base of such a prism must depend on the ratio between the axes of the elementary spheroid.

The Cube.

Let a mass of matter be supposed to consist of spherical particles all of the same size, but of two different kinds in equal numbers, represented by black and white balls; and let it be required that, in their perfect intermixture, every black ball shall be equally distant from all surrounding white balls, and that all adjacent balls of the same denomination shall also be equidistant from each other. The doctor shows, that these conditions will be fulfilled if the arrangement be cubical, and that the particles will be *in equilibrio*. Fig. 14. represents a cube so constituted of balls, alternately black and white throughout. The four black balls are all in view. The distances of their centres being every way a superficial diagonal of the cube, they are equidistant, and their configuration represents a regular tetrahedron; and the same is the relative situation of the four white balls. The distances of dissimilar adjacent balls are likewise evidently equal; so that the conditions of their union are complete, as far as appears in the small group: and this is a correct representative of the entire mass, that would be composed of equal and similar cubes.

There remains one observation with regard to the spherical form of elementary particles, whether actual or virtual, that must be regarded as favourable to the foregoing hypothesis, namely, that many of those substances which we have most reason to think simple bodies, as among the class of metals, exhibit this further evidence of their simple nature, that they crystallize in the octohedral form as they would do if their particles were spherical.

But it must, on the contrary, be acknowledged that we can at present assign no reason why the same appearance of simplicity should take place in fluor spar, which is presumed to contain at least two elements; and it is evident, that any attempts to trace a general correspondence between the crystallographical and supposed chemical elements of bodies, must, in the present state of these sciences, be premature.

Any sphere when not compressed will be surrounded by twelve others, and, consequently by a slight degree of compression, will be converted into a dodecahedron, according to the most probable hypothesis of simple compression.

The instrument for measuring the angles of crystals is called a goniometer, of which there are two kinds. 1. The goniometer of M. Carangeau, used by M. Haüy, consists of two parallel blades, jointed like those of scissars, and capable of being applied to a graduated semicircular sector, which gives the angle to which the joint is opened, in consequence of the previous apposition of the two blades to the angle of the crystal. 2. The reflective goniometer of Dr. Wollaston; an admirable invention, which measures the angles of the minutest possible crystals with the utmost precision. An account of this beautiful instrument may be found in the Phil. Trans. for 1809, and in Tilloch's Magazine for February 1810, vol. 35. Mr. William Phillips published, in the 2d volume of the Geological Transactions, an elaborate series of measurements with this goniometer. A striking example of the power of this instrument in detecting the minutest forms with precision was afforded by its application to a crystalline jet-black sand, which Dr. Clark got from the island Jean Mayen, in the Greenland seas. "Having therefore," says Dr. Clarke, "selected a crystal of this form, but so exceedingly minute as scarcely to be discernible to the naked eye, I fixed it upon the moveable plane of Dr. Wollaston's reflecting goniometer. A double image was reflected by one of the planes of the crystal, but the image reflected by the contiguous plane was clear and perfectly perceptible, by which I was enabled to measure the angle of inclination; and after repeating the observation several times, I found it to equal 92° or 92½°. Hence it is evident that these crystals are not zircons, although they possess a degree of lustre quite equal to that of zircon. In this uncertainty, I sent a small portion of the sand to Dr. Wollaston, and requested that he would himself measure the *angle* of the particles exhibiting splendent surfaces. Dr. Wollaston pronounced the substance to be pyroxene; having an angle, according to his observation, of 92½°. He also informed me that the sand was similar to that of Bolsenna in Italy." Such a ready means of minute research forms a delightful aid to the chemical philosopher, as well as the mineralogist. M. Haüy, by a too rigid adherence to the principle of geometrical simplicity, obtained an erroneous determination of the angles in the primary form of carbonate of lime, amounting to 36 minutes of a degree. And by assigning to the magnesian and ferriferous carbonates of lime the same angle as to the simple carbonate, the error became still greater, as will appear from the following comparative measurements.

	Observed angle by Dr. Wollaston's goniometer.	Theoretic angle.	Error.
Carbonate of lime,	105° 5′	104° 28′ 40″	0° 36′ 20″
Magnesian carbonate,	106 15	104 28 40	1 46 20
Ferriferous carbonate,	107 0	104 28 40	2 31 20

M. Haüy will no doubt accommodate his results to these indications of Dr. Wollaston's goniometer, and give his theory all the perfection which its scientific value and elegance deserve.

M. Beudant has lately made many experiments to discover why a saline principle of a certain kind sometimes impresses its crystalline form upon a mixture in which it does not, by any means, form the greatest part; and also with the view of determining, why one saline substance may have such an astonishing number of secondary forms as we sometimes meet with.

The presence of urea makes common salt take an octohedral form, although in pure water it crystallizes in cubes similar to its primitive molecules. Sal ammoniac, which crystallizes in pure water in octohedrons, by means of urea crystallizes in cubes. A very slight excess or deficiency of base in alum causes it to assume either cubical or octohedral secondary forms; and these forms are so truly secondary, that an octohedral crystal of alum, immerged in a solution which is richer in respect to its basis, becomes enveloped with crystalline layers, which give it at length the form of a cube.

The crystalline form, in muddy solutions acquires greater simplicity, losing all those additional *facets*, which would otherwise modify their predominant form.

In a gelatinous deposite, crystals are rarely found in groups, but almost always single, and of a remarkable sharpness and regularity of form; and they do not undergo any variations but those which may result from the chemical action of the substance forming the deposite. Common salt crystallized in a solution of borax acquires truncations at the solid angles of its cubes; and alum crystallized in muriatic acid takes a form which M. Beudant has never been able to obtain in any other manner.

30 or 40 per cent. of sulphate of copper may be united to the rhomboidal crystallization of sulphate of iron, but it reduces this sulphate to a pure rhomboid, without any truncation either of the angles or the edges. A small portion of acetate of copper reduces sulphate of iron to the same simple rhomboidal form, notwithstanding that this form is disposed to become complicated with additional surfaces. Sulphate of alumina brings sulphate of iron to a rhomboid, with the lateral angles only truncated, or what M. Haüy calls his *variété unitaire;* and whenever this variety of green vitriol is found in the market, where it is very common, we may be sure, according to M. Beudant, that it contains alumina.

Natural crystals mixed with foreign substances are in general more simple than others, as is shown in a specimen of axinite or violet schorl of Dauphiné, one extremity of which being mixed with chlorite is reduced to its primitive form; while the other end, which is pure, is varied by many facets produced by different decrements.

In a mingled solution of two or more salts, of nearly equal solubility, the crystallization of one of them may be sometimes determined by laying or suspending in the liquid a crystal of that particular salt.

M. Le Blanc states, that, on putting into a tall and narrow cylinder, crystals at different heights, in the midst of their saturated saline solution, the crystals at the bottom increase faster than those at the surface, and that there arrives a period when those at the bottom continue to enlarge, while those at the surface diminish and dissolve.

Those salts which are apt to give up their water of crystallization to the atmosphere, and of course become efflorescent, may be preserved by immersion in oil, and subsequent wiping of their surface.

In the Wernerian language of crystallization, the following terms are employed: When a secondary form differs from the cube, the octohedron, &c. only in having several of its angles or edges replaced by a face, this change of the geometrical form is called a *truncation*. The alteration in the principal form produced by two new faces inclined to one another, and which replace by a kind of bevel, an angle, or an edge, is called a *bevelment*. When these new faces are to the number of three or more, they produce what Werner termed a *pointing*, or *acumination*. When two faces unite by an edge in the manner of a roof, they have been called *culmination*. *Replacement* is occasionally used for *bevelment*.

The reader will find some curious observations on crystallization, by Mr. J. F. Daniell, in the 1st vol. of the Journal of Science.

Professor Mohs, successor to Werner in Freyberg, Dr. Weiss, professor of mineralogy in Berlin, and M. Brochant, professor of mineralogy in Paris, have each recently published systems of mineralogy. Pretty copious details, relative to the first, are given in the 3rd volume of the Edinburgh Philosophical Journal.

A complete exposition of this system will be found in M. Haidinger's able translation of Mohs.

In a paper in the Journal de Physique, M. Le Blanc gives instructions for obtaining crystals of large size. His method is to employ flat glass or china vessels: to pour into these the solutions boiled down to the point of crystallization: to select the neatest of the small crystals formed, and put them into vessels with more of the mother-water of a solution that has been brought to crystallize confusedly: to turn the crystals at least once a-day; and to supply them from time to time with fresh mother-water. If the crystals be laid on their sides, they will increase most in length; if on their ends, most in breadth. When they have ceased to grow larger, they must be taken out of the liquor, or they will soon begin to diminish. It may be observed in general, that very large crystals are less transparent than those that are small.

The crystals of metals may be obtained by fusing them in a crucible with a hole in its bottom, closed by a stopper, which is to be drawn out after the vessel has been removed from the fire, and the surface of the metal has begun to congeal. The same effect may be observed if the metal be poured into a plate or dish, a little inclined, which is to be suddenly inclined in the opposite direction, as soon as the metal begins to congeal round its edges. In the first method, the fluid part of the metal runs out of the hole, leaving a kind of cup lined with crystals: in the latter way, the superior part, which is fluid, runs off, and leaves a plate of metal studded over with crystals.

The operation of crystallizing, or crystallization, is of great utility in the purifying of various saline substances. Most salts are suspended in water in greater quantities at more elevated temperatures, and separate more or less by cooling. In this property, and likewise in the quantity of salt capable of being suspended in a given quantity of water, they differ greatly from each other. It is therefore practicable in general to separate salts by due management of the temperature and evaporation. For example, if a solution of nitre and common salt be evaporated over the fire, and a small quantity be now and then taken out for trial, it will be found, at a certain period of the concentration, that a considerable portion of salt will separate by cooling, and that this salt is for the most part pure nitre. When this is seen, the whole fluid may be cooled to separate part of the nitre, after which, evaporation may be proceeded upon as before. This manipulation depends upon the different properties of the two salts with regard to their solubility and crystallization in like circumstances. For nitre is considerably more soluble in hot than in cold water, while common salt is scarcely more soluble in the one case than in the other. The common salt consequently separates in crystals as the evaporation of the heated fluid goes on, and is taken out with a ladle from time to time, whereas the nitre is separated by successive coolings at proper periods.

CUBE ORE. Hexahedral Olivenite. Wurfelerz.—*Wern.* This mineral has a pistacio-green colour, of various shades. It occurs massive, and crystallized in the perfect cube; in a cube with four diagonally opposite angles truncated; or in one truncated on all its angles; or finally, both on its edges and angles.

The crystals are small, with planes smooth and splendent. Lustre glistening. Cleavage parallel with the truncations of the angles. Translucent. Streak straw-yellow. Harder than gypsum. Easily frangible. Sp. gr. 3.0. Fuses with disengagement of arsenical vapours. Its constituents are, 31 arsenic acid, 45.5 oxide of iron, 9 oxide of copper, 4 silica, and 10.5 water, by Chenevix. Vauquelin's analysis gives no copper nor silica, but 48 iron, 18 arsenic acid, 2 to 3 carbonate of lime, and 32 water. It is found in veins, accompanied with iron-shot quartz, in Tincroft, and various other mines of Cornwall, and at St. Leonard in the Haut-Vienne in France. As an arseniate of iron, it might be ranked among the ores of either this metal or arsenic.—*Jameson.*

CUDBEAR. See Archil.

CUPEL. A shallow earthen vessel, somewhat resembling a cup, from which it derives its name. It is made of phosphate of lime, or the residue of burned bones rammed into a mould, which gives it its figure. This vessel is used in assays wherein the precious metals are fused with lead, which becomes converted into glass, and carries the impure alloy with it. See Assay.

CUPELLATION. The refining of gold by scorification with lead upon the cupel, is called cupellation. See Assay.

CURD. The coagulum which separates from milk upon the addition of acid or other substances. See Milk.

CYANITE, or KYANITE. Disthene of Haüy. Its principal colour is Berlin-blue, which passes into grey and green. It occurs massive and disseminated, also in distinct concretions. The primitive form of its crystals is an oblique four-sided prism; and the secondary forms are, an oblique four-sided prism, truncated on the lateral edges, and a twin crystal. The planes are streaked, splendent, and pearly. Cleavage threefold. Translucent or transparent. Surface of the broader lateral planes as hard as apatite; that of the angles, as quartz. Easily frangible. Spec. grav. 3.5. When pure it is idio-electric. Some crystals by friction acquire negative, others positive electricity; hence, Haüy's name. It is infusible before the blowpipe. It consists, by Klaproth, of 43 silica, 55.5 alumina, 0.50 iron, and a trace of potash. It occurs in the granite and mica slate of primitive mountains. It is found near Banchory in Aberdeenshire, and Bocharm in Banffshire; at Airolo on St. Gothard, and in various countries of Europe, as well as in Asia and America. It is cut and polished in India as an inferior sort of sapphire.—*Jameson.*

CYANOGEN. The compound base of prussic acid. The term signifies *the producer of blue.* This production of blue is never the result of the direct action of this substance on any other single body; but an indirect and unexplained operation of it in conjunction with iron, hydrogen, and oxygen. The same reason which leads to the term cyanogen would warrant us in calling it leucogen, erythrogen, or chlorogen; for it produces white, red, or green, with other metals, if it produce blue with iron. Yet, deference is due to the nomenclature of so distinguished a chemist as M. Gay Lussac. Cyanogen, like chlorine and iodine, by its action on potassium, produces flame, and like them is acidified by hydrogen. Its discovery and investigation do the highest honour to M. Gay Lussac.

Cyanogen is obtained by decomposing the cyanide of mercury by heat. But as this varies in its composition, we shall begin by describing its formation.

By digesting red oxide of mercury with prussian blue and hot water, we obtain a cyanide perfectly neutral, which crystallizes in long four-sided prisms, truncated obliquely. By repeated solutions and crystallizations, we may free it from a small portion of adhering iron. But M. Gay Lussac prefers boiling it with red oxide of mercury, which completely precipitates the oxide of iron, and he then saturates the excess of oxide of mercury with a little prussic acid, or a little muriatic acid. The cyanide thus formed is decomposed by heat to obtain the radical. For common experiments we may dispense with these precautions.

When this cyanide is boiled with red oxide of mercury, it dissolves a considerable quantity of the oxide, becomes alkaline, crystallizes no longer in prisms, but in small scales, and its solubility in water appears a little increased. When evaporated to dryness, it is very easily charred, which obliges us to employ the heat merely of a water bath. This compound was observed by M. Proust. When decomposed by heat, it gives abundance of cyanogen, but mixed with carbonic acid gas. Proust says, that it yields ammonia, oil in considerable abundance, carbonic acid, azote, and oxide of carbon. He employed a moist cyanide. Had it been dry, the discovery of cyanogen could hardly have escaped him. The cyanide of mercury, when neutral and quite dry, gives nothing but cyanogen; when moist, it furnishes only carbonic acid, ammonia, and a great deal of prussic acid vapour. When we employ the cyanide made with excess of peroxide, the same products are obtained, but in different proportions, along with azote, and a brown liquid, which Proust took for an oil, though it is not one in reality. Hence, to obtain pure cyanogen, we must employ the neutral cyanide in a state of perfect dryness. The other mercurial compound is not, however, simply a sub-cyanide. It is a compound of oxide of mercury and the cyanide, analogous to the brick-coloured precipitate obtained by adding a little potash to the solution of deutochloride of mercury (corrosive sublimate), which is a triple compound of chlorine, oxygen, and mercury, or a binary compound of oxide of mercury with the chloride of that metal. These compounds might be called oxycyanide and oxychloride of mercury.

When the simple mercurial cyanide is exposed to heat in a small glass retort, or tube, shut at one extremity, it soon begins to blacken. It appears to melt like an animal matter, and then the cyanogen is disengaged in abundance. This gas is pure from the beginning of the process to the end, provided always that the heat be not very high; for if it were sufficiently intense to melt the glass, a little azote would be evolved. Mercury is volatilized with a considerable quantity of cyanide, and there remains a charry matter of the colour of soot, and as light as lampblack. The cyanide of silver gives out likewise cyanogen when heated; but the mercurial cyanide is preferable to every other.

Cyanogen is a permanently elastic fluid. Its smell, which it is impossible to describe, is very strong and penetrating. Its solution in water has a very sharp taste. The gas burns with a bluish flame mixed with purple. Its specific gravity, compared to that of air, is 1.8064. M. Gay Lussac obtained it by weighing at the same temperature, and under the same pressure, a balloon of about 2½ litres (152.56 cubic inches), in which the vacuum was made to the same degree, and alternately full of air and cyanogen. 100 cubic inches weigh therefore 55.1295 grains.

Cyanogen is capable of sustaining a pretty high heat, without being decomposed. Water, with which M. Gay Lussac agitated it for some minutes, at the temperature of 68°, absorbed about 4½ times its volume. Pure alcohol absorbs 23 times its volume. Sulphuric ether and oil of turpentine dissolve at least as much as water. Tincture of litmus is reddened by cyanogen. On heating the solution the gas is disengaged, mixed with a little carbonic acid, and the blue colour of the litmus is restored. The carbonic acid proceeds no doubt from the decomposition of a small quantity of cyanogen and water. It deprives the red sulphate of manganese of its colour, a property which prussic acid does not possess. This is a proof that its elements have more mobility than those of the acid. In the dry way, it separates the carbonic acid from the carbonates.

Phosphorus, sulphur, and iodine, may be sublimed by the heat of a spirit-lamp in cyanogen, without occasioning any change on it. Its mixture with hydrogen was not altered by the same temperature, or by passing electrical sparks through it. Copper and gold do not combine with it; but iron, when heated almost to whiteness, decomposes it in part. The metal is covered with a slight coating of charcoal, and becomes brittle. The undecomposed portion of the gas is mixed with azote (contains free azote). In one trial the azote constituted 0.44 of the mixture, but in general it was less. Platinum, which had been placed beside the iron, did not undergo any alteration. Neither its surface nor that of the tube was covered with charcoal like the iron.

In the cold, potassium acts but slowly on cyanogen, because a crust is formed on its surface, which presents an obstacle to the mutual action. On applying the spirit-lamp, the potassium becomes speedily incandescent; the absorption of the gas begins, the inflamed disc gradually diminishes, and when it disappears entirely, which takes place in a few seconds, the absorption is likewise at an end. Supposing we employ a quantity of potassium that would disengage 50 parts of hydrogen from water, we find that from 48 to 50 parts of gas have disappeared. On treating the residue with potash, there usually remain 4 or 5 parts of hydrogen, sometimes 10 or 12. M. Gay Lussac made a great number of experiments to discover the origin of this gas. He thinks that it is derived from the water which the cyanide of mercury contains when it has not been sufficiently dried. Prussic acid vapour is then produced, which, when decomposed by the potassium, leaves half its volume of hydrogen. Potassium, therefore, absorbs a volume of pure cyanogen, equal to that of the hydrogen which it would disengage from water.

The compound of cyanogen and potassium is yellowish. It dissolves in water without effervescence, and the solution is strongly alkaline. Its taste is the same as that of hydrocyanate or simple prussiate of potash, of which it possesses all the properties.

The gas being very inflammable, M. Gay Lussac exploded it in Volta's eudiometer, with about 2½ times its volume of oxygen. The detonation is very strong; and the flame is bluish, like that of sulphur burning in oxygen.

Supposing that we operate on 100 parts of cyanogen, we find after the explosion a diminution of volume, which amounts to from four to nine parts. When the residuum is treated with potash or barytes, it diminishes from 195 to 200 parts, which are carbonic acid gas. The new residuum, analyzed over water by hydrogen, gives from 94 to 98 parts of azote, and the oxygen which it contains, added to that in the carbonic acid, is equal (within four or five per cent.) to that which has been employed.

Neglecting the small differences which prevent these numbers from having simple ratios to each other, and which, like the presence of hydrogen, depend upon the presence of a variable portion of prussic acid vapour in the cyanogen employed, proceeding from the water left in the cyanide of mercury, we may admit that cyanogen contains a sufficient quantity of carbon to produce twice its volume of carbonic acid gas; that is to say, two volumes of the vapour of carbon, and one volume of azote condensed into a single volume. If that supposition be exact, the density of the radical derived from it ought to be equal to the density derived from experiment; but supposing the density of air to be 1.00, twice that of the vapour of

Carbon is	0·8320	(0·8332)
Azote,	0·9691	(0·9722)
	1·8014	1·8051

From the near agreement of these numbers with the experimental density, we are entitled to conclude that M. Gay Lussac's analysis is correct. By adding a volume of hydrogen to a volume of cyanogen, we obtain two volumes of prussic acid vapour; just as by adding a volume of hydrogen to a volume of chlorine, we obtain two volumes of muriatic acid gas. The same proportions hold with regard to the vapour of iodine, hydrogen, and hydriodic acid. Hence the sp. gr. of these three hydrogen acids is exactly equal to half the sum of the densities of their respective bases and hydrogen. This analogy was first established by M. Gay Lussac.

It is now obvious that the action of potassium on cyanogen agrees with its action on prussic acid. We have seen that it absorbs 50 parts of the first, and likewise that it absorbs 100 parts of the second, from which it separates 50 parts of hydrogen. But 100 parts of prussic acid vapour, *minus* 50 parts of hydrogen, amount exactly to 50 parts cyanogen. Hence the two results agree perfectly, and the two compounds obtained ought to be identical, which agrees precisely with experiment.

The analysis of cyanogen being of great importance, M. Gay Lussac attempted it likewise by other methods. Having put cyanide of mercury into the bottom of a glass tube, he covered it with brown oxide of copper, and then raised the heat to a dull red. On heating gradually the part of the tube containing the cyanide, the cyanogen was gradually disengaged, and passed through the oxide, which it reduced completely to the metallic state. On washing the gaseous products with aqueous potash, at different parts of the process, he obtained only from 0.19 to 0.30 of azote, instead of 0.33, which ought to have remained according to the preceding analysis. Presuming that some nitrous compound had been formed, he repeated the experiment, covering the oxide with a column of copper filings, which he kept at the same temperature as the oxide. With this new arrangement, the results were very singular; for the smallest quantity of azote which he obtained during the whole course of the experiment was 32·7 for 100 of gas, and the greatest was 34·4. The mean of all the trials was,—

Azote,	33·6 or nearly	1
Carbonic acid,	66·4	2

A result which shows clearly that cyanogen contains two volumes of the vapour of carbon, and one volume of azote.

In another experiment, instead of passing the cyanogen through the oxide of copper, he made a mixture of one part of the cyanide of mercury, and 10 parts of the red oxide, and after introducing it into a glass tube, close at one end, he covered it with copper filings, which he raised first to a red heat. On heating the mixture successively, the decomposition went on with the greatest facility. The proportions of the gaseous mixture were less regular than in the preceding experiment. Their mean was,—

Azote,	34·6 instead of	33·3
Carbonic acid,	65·4	66·6

In another experiment he obtained,—

Azote,	32.2
Carbonic acid,	67·8

Now the mean of these results gives,—

Azote,	33·4
Carbonic acid,	66·6

No sensible quantity of water seemed to be formed during these analyses. This shows farther, that what has been called a prussiate of mercury is really a cyanide of that metal.

When a pure solution of potash is introduced into this gas, the absorption is rapid. If the alkali be not too concentrated, and be not quite saturated, it is scarcely tinged of a lemon-yellow colour. But if the cyanogen be in excess, we obtain a brown solution, apparently carbonaceous. On pouring potash combined with cyanogen into a saline solution of a black oxide of iron, and adding an acid, we obtain prussian blue. It would appear from this phenomenon that the cyanogen is decomposed the instant that it combines with the potash: but this conclusion is premature; for when this body is really decomposed by means of an alkaline solution, carbonic acid is always produced, together with prussic acid and ammonia. But on pouring barytes into a solution of cyanogen in potash, no precipitate takes place, which shows that no carbonic acid is present. On adding an excess of quicklime, no trace of ammonia is perceptible. Since, then, no carbonic acid and ammonia have been formed, water has not been decomposed, and consequently no prussic acid evolved. How then comes the solution of cyanogen in potash to produce prussian blue, with a solution of iron and acid? The following is M. Gay Lussac's solution of this difficulty:—

The instant an acid is poured into the solution of cyanogen in potash, a strong effervescence of carbonic acid is produced, and at the same time a strong smell of prussic acid becomes perceptible. Ammonia is likewise formed, which remains combined with the acid employed, and which may be rendered very sensible to the smell by the addition of quicklime. Since therefore we are obliged to add an acid in order to form prussian blue, its formation occasions no farther difficulty.

Soda, barytes, and strontites, produce the same effect as potash. We must therefore admit that cyanogen forms particular combinations with the alkalis, which are permanent till some circumstance determines the formation of new products. These combinations are true salts, which may be regarded as analogous to those formed by acids. In fact cyanogen possesses acid characters. It contains two elements, azote and carbon, the first of which is strongly acidifying, according to M. Gay Lussac. (Is it not as strongly alkalifying, with hydrogen, in ammonia?) Cyanogen reddens the tincture of litmus, and neutralizes the bases. On the other hand, it acts as a simple body when it combines with hydrogen; and it is this double function of a simple and compound body which renders its nomenclature so embarrassing.

Be this as it may, the compounds of cyanogen and the alkalis, which may be distinguished by the term cyanides, do not separate in water, like the alkaline chlorides, (oxymuriates), which produce chlorates and muriates. But when an acid is added, there is formed, 1st, Carbonic acid, which corresponds to the chloric acid; 2d, Ammonia and prussic acid, which correspond to the muriatic.

When the cyanide of potash is decomposed by an acid, there is produced a volume of carbonic acid just equal to that of the cyanogen employed. What then becomes of the other volume of the vapour of carbon; for the cyanogen contains two, with one volume of azote?

Since there is produced, at the expense of the oxygen of the water, a volume of carbonic acid, which represents 1 volume of oxygen, 2 volumes of hydrogen must likewise have been produced. Therefore, neglecting the carbonic acid, there remains

1	volume vapour of carbon,
1	azote,
2	hydrogen;

and we must make these three elements combine in totality, so as to produce only prussic acid and ammonia. But the one volume of the vapour of carbon, with half a volume of azote, and half a volume of hydrogen, produces exactly 1 volume of prussic acid, while the volume and a half of hydrogen, and the half volume of azote remaining, produce 1 volume of ammoniacal gas; for this substance is formed of 3 volumes of hydrogen and 1 of azote, condensed into 2 volumes. See AMMONIA.

A given volume of cyanogen, then, combined first with an alkali, and then treated with an acid, produces exactly

1 volume of carbonic acid gas,
1 prussic acid vapour,
1 ammoniacal gas.

It is very remarkable to see an experiment, apparently very complicated, give so simple a result.

The metallic oxides do not seem capable of producing the same changes on cyanogen as the alkalis. Having precipitated proto-sulphate of iron by an alkali, so that no free alkali remained, M. Gay Lussac caused the oxide of iron (mixed necessarily with much water) to absorb cyanogen, and then added muriatic acid. But he did not obtain the slightest trace of prussian blue; though the same oxide, to which he had added a little potash before adding the acid, produced it in abundance.

From this result one is induced to believe that oxide of iron does not combine with cyanogen; and so much the more, because water impregnated with this gas never produces prussian blue with solution of iron, unless we begin by adding an alkali. See ACID (PRUSSIC). The peroxides of manganese and mercury, and the deutoxide of lead, absorb cyanogen, but very slowly. If we add water, the combination is much more rapid. With the peroxide of mercury, we obtain a greyish-white compound, somewhat soluble in water.

Cyanogen rapidly decomposes the carbonates at a dull red heat, and cyanides of the oxides are obtained. When passed through sulphuret of barytes, it combines without disengaging the sulphur, and renders it very fusible, and of a brownish-black colour. When put into water, we obtain a colourless solution, but which gives a deep brown (maroon) colour to muriate of iron. What does not dissolve contains a good deal of sulphate, which is doubtless formed during the preparation of the sulphuret of barytes.

On dissolving cyanogen in the sulphuretted hydrosulphuret of barytes, sulphur is precipitated, which is again dissolved when the liquid is saturated with cyanogen, and we obtain a solution having a very deep brown maroon colour. This gas does not decompose sulphuret of silver, nor of potash.

Cyanogen and sulphuretted hydrogen combine slowly with each other. A yellow substance is obtained in fine needles, which dissolves in water, does not precipitate nitrate of lead, produces no prussian blue, and is composed of 1 volume cyanogen, and $1\frac{1}{2}$ volume of sulphuretted hydrogen.

Ammoniacal gas and cyanogen begin to act on each other whenever they come in contact; but some hours are requisite to render the effect complete. We perceive at first a white thick vapour, which soon disappears. The diminution of volume is considerable, and the glass in which the mixture is made becomes opaque, its inside being covered with a solid brown matter. On mixing 90 parts of cyanogen, and 227 ammonia, they combined nearly in the proportion of 1 to $1\frac{1}{2}$. This compound gives a dark orange-brown colour to water, but dissolves only in a very small proportion. The liquid produces no prussian blue with the salts of iron.

When prussic acid is exposed to the action of a voltaic battery of 20 pairs of plates, much hydrogen gas is disengaged at the negative pole, while nothing appears at the positive pole. It is because there is evolved at that pole cyanogen, which remains dissolved in the acid. We may, in this manner, attempt the combination of metals with cyanogen, placing them at the positive pole.

It is easy now to determine what takes place when an animal matter is calcined with potash or its carbonate. A cyanide of potash is formed. It has been proved, that by heat potash separates the hydrogen of the prussic or hydrocyanic acid. We cannot then suppose that this acid is formed, while a mixture of potash and animal matters is exposed to a high temperature. But we obtain a cyanide of potash, and not of potassium; for this last, when dissolved in water, gives only prussiate of potash (hydro-cyanate), which is decomposed by the acids, without producing ammonia and carbonic acid; while the cyanide of potash dissolves in water, without being altered, and does *not* give ammonia, carbonic acid, and prussic (hydrocyanic) acid vapour, unless an acid be added. This is the character which distinguishes a cyanide of a metal from a cyanide of a metallic oxide. See ACID (PRUSSIC).

The preceding facts are taken from M. Gay Lussac's memoir on hydrocyanic acid, presented to the Institute, September 18, 1815, and published in the Annales de Chimie, vol. xcv.

In the Journal de Pharmacie for November, 1818, M. Vaúquelin has published an elaborate dissertation on the same subject, of which I have given some extracts under ACID (PRUSSIC). I shall insert here his very elegant process for obtaining pure hydrocyanic or prussic acid, from the cyanide of mercury.

Considering that mercury has a strong attraction for sulphur, and that cyanogen unites easily to hydrogen, when presented in the proper state, he thought that sulphuretted hydrogen might be employed for decomposing dry cyanide of mercury. He operated in the following way:—He made a current of sulphuretted hydrogen gas, disengaged slowly from a mixture of sulphuret of iron, and very dilute sulphuric acid, pass slowly through a glass tube slightly heated, filled with the mercurial cyanide, and communicating with a receiver, cooled by a mixture of salt and snow.

As soon as the sulphuretted hydrogen came in contact with the mercurial salt, this last substance blackened, and this effect gradually extended to the farthest extremity of the apparatus. During this time no trace of sulphuretted hydrogen could be perceived at the mouth of a tube proceeding from the receiver. As soon as the odour of this gas began to be perceived, the process was stopped; and the tube was heated in order to drive over the acid which might still remain in it. The apparatus being unluted, he found in the receiver a colourless fluid, which possessed all the known properties of prussic acid. It amounted to nearly the fifth part of the cyanide of mercury employed.

This process is easier, and furnishes more acid, than M. Gay Lussac's by means of muriatic acid. He repeated it several times, and always successfully. It is necessary merely to take care to stop the process before the odour of the sulphuretted hydrogen begins to be perceived, otherwise the hydrocyanic acid will be mixed with it. However, we may avoid this inconvenience by placing a little carbonate of lead at the extremity of the tube. As absolute hydrocyanic acid is required only for chemical researches, and as it cannot be employed in medicine, it may be worth while, says M. Vauquelin, to bring to the recollection of apothecaries a process of M. Proust, which has, perhaps, escaped their attention. It consists in passing a current of sulphuretted hydrogen gas through a cold saturated solution of prussiate of mercury in water, till the liquid contains an excess of it; to put the mixture into a bottle, in order to agitate it from time to time; and finally, to filter it.

If this prussic acid, as almost always happens, contains traces of sulphuretted hydrogen, agitate it with a little carbonate of lead, and filter it again. By this process we may obtain hydrocyanic acid in a much greater degree of concentration than is necessary for medicine. It has the advantage over the dry prussic acid, of being capable of being preserved a long time, always taking care to keep it as much as possible from the contact of air and heat. See Acid (Prussic).

In the first volume of the Journal of Science and the Arts, Sir H. Davy has stated some interesting particulars relative to cyanogen. By heating cyanide of mercury in muriatic acid gas, he obtained pure liquid prussic acid, and corrosive sublimate. By heating iodine, sulphur, and phosphorus, in contact with cyanide of mercury, compounds of these bodies with cyanogen may be formed. That of iodine is a very curious body. It is volatile at a very moderate heat, and on cooling collects in flocculi, adhering together like oxide of zinc formed by combustion. It has a pungent smell, and very acrid taste.

A portion of pure cyanide of mercury was heated till perfectly dry, and then inclosed in a green glass tube (see Acid Carbonic), and being collected to one end, was decomposed by heat, whilst the other end was *cooled*. The cyanogen soon appeared as a *liquid*, limpid, colourless, and very fluid; not altering its state at 0° F. A tube containing it being opened in the air, the expansion within did not seem to be very great; and the liquid passed with comparative slowness into the state of vapour, producing great cold. The vapour collected over mercury proved to be pure cyanogen.

Liquid cyanogen, evolved in contact with moisture, does not mix with the water, but floats over it. In a few days, the water and cyanogen react on each other, and carbonaceous matter is evolved. *Mr. Faraday*, *Phil. Trans.* 1823.

CYMOPHANE of Haüy. The Chrysoberyl.

CYSTIC OXIDE. See Calculus (Urinary).

D

DAHLINE. A vegetable principle discovered by M. Payen, analogous to starch and inulin. To extract it, the pulp of the bulbs of Dahlia is to be diffused in its weight of water, filtered through cloth, the liquid mixed with one-twentieth its weight of common chalk, boiled for half an hour, and filtered. The residuum of the bulbs is then to be pressed, the solutions united, and evaporated to three-fourths of their volume. Four *per cent.* of animal charcoal must now be added, and the whole clarified by the white of an egg. The liquor filtered and evaporated, until a film form on the surface, deposits dahlin on cooling. All the washings are to be treated in the same way, and thus 4 *per cent.* of dahline will be obtained from the bulbs.

This substance when pure is white, inodorous, pulverulent, tasteless, sp. gr. 1.356, more soluble in hot than cold water, *not* soluble in alkohol, but precipitated by it from aqueous solutions. It differs from starch and inulin in forming a granulated mass when its aqueous solution is evaporated, as also in its specific gravity. M. Braconnot has discovered dahlin in the Jerusalem artichoke. He considers it merely as a variety of inulin. *Annales de Chim. et Phys.* xxiv. and xxv.

DAMPS. The permanently elastic fluids which are extricated in mines, and are destructive to animal life, are called damps by the miners. The chief distinctions made by the miners are, choke-damp, which extinguishes their candles, hovers about the bottom of the mine, and consists for the most part of carbonic acid gas; and fire-damp, or carburetted hydrogen, which occupies the superior spaces, and does great mischief by exploding whenever it comes in contact with their lights. See GAS, COMBUSTION, and LAMP.

DAOURITE. A variety of red schorl from Siberia.

DAPHNIN. The bitter principle of *Daphne Alpina*, discovered by M. Vauquelin. From the alcoholic infusion of this bark, the resin was separated by its concentration. On diluting the tincture with water, filtering, and adding acetate of lead, a yellow *daphnate* of lead fell, from which sulphuretted hydrogen separated the lead, and left the daphnin in small transparent crystals. They are hard, of a greyish colour, a bitter taste when heated, evaporate in acrid acid vapours, sparingly soluble in cold, but moderately in boiling water. It is stated, that its solution is not precipitated by acetate of lead; yet acetate of lead is employed in the first process to throw it down.

DATOLITE. Datholit of Werner. This species is divided into two sub-species, viz. Common Datolite, and Botroidal Datolite.

1. *Common Datolite*. Colour white of various shades, and greenish-grey, inclining to celadine-green. It occurs in large coarse, and small granular distinct concretions, and crystallized. Primitive form, an oblique four-sided prism of 109° 28′, and 70° 32′. The principal secondary forms are, the low oblique four-sided prism, and the rectangular four-sided prism, flatly acuminated on the extremities, with four planes which are set on the lateral planes. The crystals are small and in druses. Lustre shining and resinous. Cleavage imperfect, parallel with the lateral planes of the prism. Fracture fine-grained, uneven, or imperfect conchoidal. Translucent or transparent. Fully as hard as apatite. Very brittle and difficultly frangible. Sp. gr. 2.9. When exposed to the flame of a candle it becomes opaque, and may then be rubbed down between the fingers. Before the blowpipe it intumesces into a milk-white coloured mass, and then melts into a globule of a pale rose colour. Its constituents are, by Klaproth, silica 36.5, lime 35.5, boracic acid 24.0, water 4, trace of iron and manganese. It is associated with large foliated granular calcareous spar, at the mine of Nodebroe, near Arendal in Norway. It resembles prehnite, but is distinguished by resinous lustre, compact fracture, inferior hardness, and not becoming electric by heating.—*Jameson*.

2. *Botroidal Datolite*. See BOTRYOLITE.

DATURA. A supposed vegeto-alkali obtained from DATURA STRAMONIUM.

DEAD-SEA WATER. See WATER.

DECANTATION. The action of pouring off the clearer part of a fluid by gently inclining the vessel after the grosser parts have been suffered to subside.

DECOCTION. The operation of boiling. This term is likewise used to denote the fluid itself, which has been made to take up certain soluble principles by boiling. Thus we say a decoction of the bark, or other parts of vegetables, of flesh, &c.

DECOMPOSITION is now understood to imply the separation of the component parts or principles of bodies from each other.

The decomposition of bodies forms a very large part of chemical science. It seems probable from the operations we are acquainted with, that it seldom takes place but in consequence of some combination or composition having been effected. It would be difficult to point out an instance of the separation of any of the principles of bodies which has been effected, unless in consequence of some new combination. The only exceptions seem to consist in those separations which are made by heat, and voltaic electricity. See ANALYSIS, GAS, METALS, ORES, SALTS, MINERAL WATERS.

DECREPITATION. The crackling noise which several salts make when suddenly heated, accompanied by a violent exfoliation of their particles. This phenomenon has been ascribed to the "sudden conversion of the water which they contain into steam." But the very example, sulphate of barytes, to which these words are applied, is the strongest evidence of the falseness of the explanation; for absolutely dry sulphate of barytes decrepitates furiously without any possible formation of steam, or any loss of weight. The same thing holds with regard to common salt, calcareous spars, and sulphate of potash, which contain *no water*. In fact, it is the salts which are anhydrous, or destitute of water, which decrepitate most powerfully; those that contain water generally enter into tranquil liquefaction on being heated. Salts decrepitate, for the same reason that glass, quartz, and cast-iron crack, with an explosive force, when very suddenly heated; namely, from the unequal expansion of the laminæ which compose them, in consequence of their being imperfect conductors of heat. The true cleavage of minerals may often be detected in this way, for they fly asunder at their natural fissures.

DELPHINITE. See PISTACITE.

DELPHINIA. A new vegetable alkali recently discovered by MM. Lasseigne and Feneulle, in the *Delphinium staphysagria*, or Stavesacre. It is thus obtained:

The seeds, deprived of their husks, and ground, are to be boiled in a small quantity of distilled water, and then pressed in a cloth. The decoction is to be filtered, and boiled for a few minutes with pure magnesia. It must then be re-filtered, and the residuum left on the filter is to be well washed, and then boiled with highly rectified alcohol, which dissolves out the alkali. By evaporation, a white pulverulent substance, presenting a few crystalline points, is obtained.

It may also be procured by the action of dilute sulphuric acid, on the bruised but unshelled seeds. The solution of sulphate thus formed is precipitated by subcarbonate of potash. Alcohol separates from this precipitate the vegetable alkali in an impure state.

Pure delphinia obtained by the first process is crystalline while wet, but becomes opaque on exposure to air. Its taste is bitter and acrid. When heated it melts; and on cooling becomes hard and brittle like resin. If more highly heated, it blackens and is decomposed. Water dissolves a very small portion of it. Alcohol and ether dissolve it very readily. The alcoholic solution renders syrup of violets green, and restores the blue tint of litmus reddened by an acid. It forms soluble neutral salts with acids. Alkalis precipitate the delphinia in a white gelatinous state, like alumina.

Sulphate of delphinia evaporates in the air, does not crystallize, but becomes a transparent mass like gum. It dissolves in alcohol and water, and its solution has a bitter acrid taste. In the voltaic circuit it is decomposed, giving up its alkali at the negative pole.

Nitrate of delphinia, when evaporated to dryness, is a yellow crystalline mass. If treated with excess of nitric acid, it becomes converted into a yellow matter, little soluble in water, but soluble in boiling alcohol. This solution is bitter, is not precipitated by potash, ammonia, or lime-water, and appears to contain no nitric acid, though itself is not alkaline. It is not destroyed by further quantities of acid, nor does it form oxalic acid. Strychnia and morphia take a red colour from nitric acid, but delphinia never does. The muriate is very soluble in water.

The acetate of delphinia does not crystallize, but forms a hard transparent mass, bitter and acrid, and readily decomposed by cold sulphuric acid. The oxalate forms small white plates, resembling in taste the preceding salts.

Delphinia, calcined with oxide of copper, gave no other gas than carbonic acid. It exists in the seeds of the stavesacre, in combination with malic acid, and associated with the following principles: 1. A brown bitter principle, precipitable by acetate of lead. 2. Volatile oil. 3. Fixed oil. 4. Albumen. 5. Animalised matter. 6. Mucus. 7. Saccharine mucus. 8. Yellow bitter principle, not precipitable by acetate of lead. 9. Mineral salts.—*Annales de Chimie et de Physique*, vol. xii. p. 358.

DELIQUESCENCE. The spontaneous assumption of the fluid state by certain saline substances, when left exposed to the air, in consequence of the water they attract from it.

DEPHLEGMATION. Any method by which bodies are deprived of water.

DEPHLOGISTICATED. A term of the old chemistry, implying deprived of phlogiston, or the inflammable principle, and nearly synonymous with what is now expressed by *oxygenated*, or *oxidized*.

DEPHLOGISTICATED AIR. Oxygen gas.

DERBYSHIRE SPAR. A combination of calcareous earth with a peculiar acid called the FLUORIC, which see.

DESICCATION is most elegantly accomplished by means of the air-pump and sulphuric acid, as is explained under CONGELATION.

DESTRUCTIVE DISTILLATION. When organized substances, or their products, are exposed to distillation, until the whole has suffered all that the furnace can effect, the process is called destructive distillation.

DETONATION. A sudden combustion and explosion. See COMBUSTION, FULMINATING POWDERS, and GUNPOWDER.

DEW. The moisture insensibly deposited from the atmosphere on the surface of the earth.

The first facts which could lead to the just explanation of this interesting, and, till very lately, inexplicable natural phenomenon, are due to the late Mr. A. Wilson, professor of astronomy in Glasgow, and his son. The first stated, in the Phil. Trans. for 1771, that on a winter night, during which the atmosphere was several times misty and clear alternately, he observed a thermometer, suspended in the air, always to *rise* from a half to a whole degree, whenever the former state began, and to fall as much, as soon as the weather became serene. Dr. Patrick Wilson communicated, in 1786, to the Royal Society of Edinburgh, a valuable paper on hoar-frost, which was published in the first volume of their Transactions. It is replete with new and valuable observations, whose minute accuracy subsequent experience has confirmed. Dr. Wilson had previously, in 1781, described the surface of snow, during a clear and calm night, to be 16° colder than air two feet above it; and in the above paper he shows, that the deposition of dew and hoar-frost is uniformly accompanied with the production of cold. He was the first among philosophical observers who noticed this conjunction. But the different force with which different surfaces project or radiate heat being then unknown, Dr. Wilson could not trace the phenomena of dew up to their ultimate source. This important contribution to science has been lately made by Dr. Wells, in his very ingenious and masterly essay on dew.

1. *Phenomena of Dew.*

Aristotle justly remarked, that dew appears only on calm and clear nights. Dr. Wells shows that very little is ever deposited in opposite circumstances; and *that little* only when the clouds are very high. It is never seen on nights both cloudy and windy; and if in the course of the night the weather, from being serene, should become dark and stormy, dew which had been deposited will disappear. In calm weather, if the sky be partially covered with clouds, more dew will appear than if it were entirely uncovered.

Dew probably begins in the country to appear upon grass, in places shaded from the sun, during clear and calm weather, soon after the heat of the atmosphere has declined, and continues to be deposited through the whole night, and for a little after sunrise. Its quantity will depend in some measure on the proportion of moisture in the atmosphere, and is consequently greater after rain than after a long tract of dry weather; and in Europe, with southerly and westerly winds, than with those which blow from the north and the east. The direction of the sea determines this relation of the winds to dew. For in Egypt, dew is scarcely ever observed except while the northerly or Etesian winds prevail. Hence also dew is generally more abundant in spring and autumn, than in summer. And it is always very copious on those clear nights which are followed by misty mornings, which show the air to be loaded with moisture. And a clear morning, following a cloudy night, determines a plentiful deposition of the retained vapour. When warmth of atmosphere is compatible with clearness, as is the case in southern latitudes, though seldom in our country, the dew becomes much more copious, because the air then contains more moisture. Dew continues to form with increased copiousness as the night advances, from the increased refrigeration of the ground.

2. *On the cause of dew.*

Dew, according to Aristotle, is a species of rain, formed in the lower atmosphere, in consequence of its moisture being condensed by the cold of the night into minute drops. Opinions of this kind, says Dr. Wells, are still entertained by many persons, among whom is the very ingenious Professor Leslie. (*Relat. of Heat and Moisture*, p. 37. and 132.) A fact, however, first taken notice of by Gerstin, who published his treatise on dew in 1773, proves them to be erroneous; for he found that bodies a little elevated in the air often become moist with dew, while similar bodies, lying on the ground, remain dry, though necessarily, from their position, *as* liable to be wetted, by whatever falls from the heavens, as the former. The above notion is perfectly refuted by what will presently appear relative to metallic surfaces exposed to the air in a horizontal position, which remain dry, while every thing around them is covered with dew.

After a long period of drought, when the air was very still and the sky serene, Dr. Wells exposed to the sky, 28 minutes before sunset, previously weighed parcels of wool and swandown, upon a smooth, unpainted, and perfectly dry fir table, 5 feet long, 3 broad, and nearly 3 in height, which had been placed an hour before, in the sunshine, in a large level grass field. The wool, 12 minutes after sunset, was found to be 14° colder than the air, and to have acquired no weight. The swandown, the quantity of which was much greater than that of the wool, was at the same time 13° colder than the air, and was also without any additional weight. In 20 minutes more, the swandown was $14\frac{1}{2}$° colder than the neighbouring air, and was still without any increase of its weight. At the same time the grass was 15° colder than the air four feet above the ground.

Dr. Wells, by a copious induction of facts, derived from observation and experiment, establishes the proposition, *that bodies become colder than the neighbouring air* BEFORE *they are dewed.* The cold therefore which Dr. Wilson and Mr. Six conjectured to be the effect of dew, now appears to be its cause. But what makes the terrestrial surface colder than the atmosphere? The radiation or projection of heat into free space. Now the researches of Professor Leslie and Count Rumford have demonstrated, that different bodies project heat with very different degrees of force.

In the operation of this principle, therefore, conjoined with the power of a concave mirror of cloud, or any other awning, to reflect or throw down again those calorific emanations which would be dissipated in a clear sky, we shall find a solution of the most mysterious phenomena of dew. Two circumstances must here be considered:—

1. The exposure of the particular surface to be dewed, to the free aspect of the sky.

2. The peculiar radiating power of the surface. 1. Whatever diminishes the view of the sky, as seen from the exposed body, obstructs the depression of its temperature, and occasions the quantity of dew formed upon it to be less than would have occurred, if the exposure to the sky had been complete.

Dr. Wells bent a sheet of pasteboard into the shape of a penthouse, making the angle of flexure 90 degrees, and leaving both ends open. This was placed one evening with its ridge uppermost, upon a grass plat in the direction of the wind, as well as this could be ascertained. He then laid 10 grains of white, and moderately fine wool, not artificially dried, on the middle part of that spot of the grass which was sheltered by the roof, and the same quantity on another part of the grass plat, fully exposed to the sky. In the morning the sheltered wool was found to have increased in weight only 2 grains, but that which had been exposed to the sky 16 grains. He varied the experiment on the same night, by placing upright on the grass plat a hollow cylinder of baked clay, 1 foot diameter, and $2\frac{1}{2}$ feet high. On the grass round the outer edge of the cylinder, were laid 10 grains of wool, which in this situation, as there was not the least wind, would have received as much rain as a like quantity of wool fully exposed to the sky. But the quantity of moisture acquired by the wool partially screened by the cylinder from the *aspect* of the sky, was only about two grains, while that acquired by the same quantity fully exposed, was 16 grains. Repose of a body seems necessary to its acquiring its utmost coolness, and a full deposite of dew. Gravel walks and pavements project heat, and acquire dew, less readily than a grassy surface. Hence wool placed on the former has its temperature less depressed than on the latter, and therefore is less bedewed. Nor does the wool here attract moisture by capillary action on the grass, for the same effect happens if it be placed in a saucer. Nor is it by hydrometric attraction; for in a cloudy night, wool placed on an elevated board acquired scarcely any increase of weight.

If wool be insulated a few feet from the ground on a bad conductor of heat, as a board, it will become still colder than when in contact with the earth, and acquire fully more dew than on the grass. At the windward end of the board, it is less bedewed than at the sheltered end, because, in the former case, its temperature is nearer to that of the atmosphere. Rough and porous surfaces, as shavings of wood, take more dew than smooth and solid wood; and raw silk and fine cotton are more powerful in this respect than even wool. Glass projects heat rapidly, and is as rapidly coated with dew. But bright metals attract dew much less powerfully than other bodies. If we coat a piece of glass, partially, with bright tin-foil, or silver leaf, the uncovered portion of the glass quickly becomes cold by radiation, on exposure to a clear nocturnal sky, and acquires moisture; which, beginning on those parts most remote from the metal, gradually approaches it. Thus also, if we coat outwardly a portion of a window pane with tinfoil, in a clear night, then moisture will be deposited inside, on every part except opposite to the metal. But if the metal be inside, then the glass under and beyond it will be sooner or most copiously bedewed. In the first case, the tin-foil prevents the glass under it from dissipating its heat, and therefore it can receive no dew; in the second case, the tin-foil prevents the glass which it coats from receiving the calorific influence of the apartment, and hence it is sooner refrigerated by external radiation than the rest of the pane. Gold, silver, copper, and tin, bad radiators of heat, and excellent conductors, acquire dew with greater difficulty than platina, which is a more imperfect conductor; or than lead, zinc, and steel, which are better radiators.

Hence dew which has formed upon a metal will often disappear, while other substances in the neighbourhood remain wet; and a metal, purposely moistened, will become dry, while neighbouring bodies are acquiring moisture. This repulsion of dew is communicated by metals to bodies in contact with or near them. Wool laid on metal acquires less dew than wool laid on the contiguous grass.

If the night becomes cloudy, after having been very clear, though there be no change with respect to calmness, a considerable alteration in the temperature of the grass always ensues. Upon one such night, the grass, after having been 12° colder than the air, became only 2° colder; the atmospheric temperature being the same at both observations. On a second night, grass became 9° warmer in the space of an hour and a half. On a third night, in less than 45 minutes the temperature of the grass rose 15°, while that of the neighbouring air increased only $3\frac{1}{2}$°. During a fourth night, the temperature of the grass, at half past 9 o'clock, was 32°. In 20 minutes afterwards, it was found to be 39°, the sky in the mean time having become cloudy. At the end of 20 minutes more, the sky being clear, the temperature of the grass was again 32°. A thermometer lying on a grass plat will sometimes rise several degrees, when a cloud comes to occupy the zenith of a clear sky.

When, during a clear and still night, different thermometers, placed in different situations, were examined at the same time, those which were situated where most dew was formed were always found to be the lowest. On dewy nights the temperature of the earth, half an inch or an inch beneath the surface, is always found much warmer than the grass upon it, or the air above it. The differences on five such nights were from 12 to 16 degrees.

In making experiments with thermometers it is necessary to coat their bulbs with silver or gold leaf, otherwise the glassy surface indicates a lower temperature than that of the air, or the metallic plate it touches. Swandown seems to exhibit greater cold, on exposure to the aspect of a clear sky, than any thing else. When grass is 14° below the atmospheric temperature, swandown is commonly 15°. Fresh unbroken straw and shreds of paper rank in this respect with swandown. Charcoal, lampblack, and rust of iron, are also very productive of cold. Snow stands 4° or 5° *higher* than swandown laid upon it in a clear night.

The following tabular view of observations by Dr. Wells is peculiar instructive:—

	6h. 45′	7. h.	7h. 20′	7h. 40′	8h. 45′
Heat of the air 4 feet above the grass,	60½°	60¾°	59°	53°	54°
——— wool on a raised board,	53½	54½	51½	48½	44½
——— swandown on the same,	54½	53	51	47½	42½
——— surface of the raised board,	58	57	55½	—	—
——— grass plat,	53	51	49½	49	42

The temperature always falls in clear nights, but the deposition of dew, depending on the moisture of the air, may occur or not. Now, if cold were the *effect* of dew, the cold connected with dew ought to be always proportional to the quantity of that fluid; but this is contradicted by experience. On the other hand, if it be granted that dew is water precipitated from the atmosphere by the cold of the body on which it appears, the same degree of cold in the precipitating body may be attended with much, with little, or with no dew, according to the existing state of the air in regard to moisture; all of which circumstances are found really to take place. The actual precipitation of dew, indeed, ought to evolve heat.

A very few degrees of difference of temperature between the grass and the atmosphere is sufficient to determine the formation of dew, when the air is in a proper state. But a difference of even 30°, or more, sometimes exists, by the radiation of heat from the earth to the heavens. And hence, the air near the refrigerated surface must be colder than that somewhat elevated. Agreeably to Mr. Six's observations, the atmosphere, at the height of 220 feet, is often, upon such nights, 10° warmer than what it is seven feet above the ground. And had not the lower air thus imparted some of its heat to the surface, the latter would have been probably 40° under the temperature of the air.

Insulated bodies, or prominent points, are sooner covered with hoar-frost and dew than others; because the equilibrium of their temperature is more difficult to be restored. As aerial stillness is necessary to the cooling effect of radiation, we can understand why the hurtful effects of cold, heavy fogs, and dews, occur chiefly in hollow and confined places, and less frequently on hills. In like manner, the leaves of trees often remain dry throughout the night, while the blades of grass are covered with dew.

No direct experiments can be made to ascertain the manner in which clouds prevent or lessen the appearance of a cold at night, upon the surface of the earth, greater than that of the atmosphere. But it may be concluded from the preceding observations, that they produce this effect almost entirely by radiating heat to the earth, in return for that which they intercept in its progress from the earth towards the heavens. The heat extricated by the condensation of transparent vapour into cloud must soon be dissipated; whereas, the effect of greatly lessening, or preventing altogether, the appearance of a greater cold on the earth than that of the air, will be produced by a cloudy sky during the whole of a long night.

We can thus explain in a more satisfactory manner than has usually been done, the sudden warmth that is felt in winter, when a fleece of clouds supervenes in clear frosty weather. Chemists ascribed this sudden and powerful change to the disengagement of the latent heat of the condensed vapours; but Dr. Wells's thermometric observations on the sudden alternations of temperature by cloud and clearness render that opinion untenable. We find the atmosphere itself, indeed, at moderate elevations, of pretty uniform temperature, while bodies at the surface of the ground suffer great variations in *their* temperature. This single fact is fatal to the hypothesis derived from the doctrines of latent heat.

"I had often," says Dr. Wells, "smiled, in the pride of half knowledge, at the means frequently employed by gardeners to protect tender plants from cold, as it appeared to me impossible that a thin mat, or any such flimsy substance, could prevent them from attaining the temperature of the atmosphere, by which alone I thought them liable to be injured. But when I had learned, that bodies on the surface of the earth become, during a still and serene night, colder than the atmosphere, by radiating their heat to the heavens, I perceived immediately a just reason for the practice which I had before deemed useless. Being desirous, however, of acquiring some precise information on this subject, I fixed perpendicularly, in the earth of a grass plat, four small sticks, and over their upper extremities, which were six inches above the grass, and formed the corners of a square whose sides were two feet long, I drew tightly a very thin cambric handkerchief. In this disposition of things, therefore, nothing existed to prevent the free passage of air from the exposed grass to that which was sheltered, except the four small sticks, and there was no substance to radiate downwards to the latter grass, except the cambric handkerchief."

The sheltered grass, however, was found nearly of the same temperature as the air, while the unsheltered was 5° or more colder. One night the fully exposed grass was 11° colder than the air; but the sheltered grass was only

3° colder. Hence we see the power of a very slight awning to avert or lessen the injurious coldness of the ground. To have the full advantage of such protection from the chill aspect of the sky, the covering should not touch the subjacent bodies. Garden walls act partly on the same principle. Snow screens plants from this chilling radiation. In warm climates, the deposition of dewy moisture on animal substances hastens their putrefaction. As this is apt to happen only in clear nights, it was anciently supposed that bright moonshine favoured animal corruption.

From this rapid emission of heat from the surface of the ground, we can now explain the formation of ice during the night in Bengal, while the temperature of the air is above 32°. The nights most favourable for this effect are those which are the calmest and most serene, and on which the air is so dry as to deposit little dew after midnight. Clouds and frequent changes of wind are certain preventives of congelation. 300 persons are employed in this operation at one place. The enclosures formed on the ground are four or five feet wide, and have walls only four inches high. In these enclosures, previously bedded with *dry* straw, broad, shallow, unglazed earthen pans are set, containing *unboiled pump-water.* Wind, which so greatly promotes evaporation, prevents the freezing altogether, and dew forms in a greater or less degree during the whole of the nights most productive of ice. If evaporation were concerned in the congelation, wetting the straw would promote it. But Mr. Williams, in the 83d vol. of the Phil. Trans. says, that it is *necessary* to the success of the process that the straw be *dry.* In proof of this he mentions, that when the straw becomes wet by accident it is renewed; and that when he purposely wetted it in some of the enclosures, the formation of ice there was always prevented. Moist straw both conducts heat and raises vapour from the ground, so as to obstruct the congelation. According to Mr. Leslie, water stands at the head of radiating substances. See CALORIC.

DIALLAGE. A species of the genus Schiller spar. Diallage has a grass-green colour. It occurs massive or disseminated. Lustre glistening and pearly. Cleavage imperfect double. Translucent. Harder than fluor spar. Brittle. Sp. gr. 3·1. It melts before the blowpipe into a grey or greenish enamel. Its constituents are 50 silica, 11 alumina, 6 magnesia, 13 lime, 5.3 oxide of iron, 1·5 oxide of copper, 7.5 oxide of chrome. *Vauquelin.* It occurs in the island of Corsica, and in Mont Rosa in Switzerland, along with saussurite. It is the *verde di Corsica duro* of artists, by whom it is fashioned into ring-stones and snuff-boxes. It is the smaragdite of Saussure.

The diallage in the rock is called *gabbro.*

DIAMOND. Colours white and grey, also red, brown, yellow, green, blue, and black. The two last are rare. When cut it exhibits a beautiful play of colours in the sunbeam. It occurs in rolled pieces, and also crystallized. 1st, In the octohedron, in which each plane is inclined to the adjacent, at an angle of 109° 28′ 16″. The faces are usually curvilinear. This is the fundamental figure. 2d, A simple three-sided pyramid, truncated on all the angles. 3d, A segment of the octohedron. 4th, Twin crystal. 5th, Octohedron, with all the edges truncated. 6th, Octohedron, flatly bevelled on all the edges. 7th, Rhomboidal dodecahedron. 8th, Octohedron with convex faces, in which each is divided into three triangular ones, forming altogether 24 faces. 9th, Octohedron, in which each convex face is divided into six planes, forming 48 in all. 10th, Rhomboidal dodecahedron, with diagonally broken planes. 11th, A flat double three-sided pyramid. 12th, Very flat double three-sided pyramid, with cylindrical convex faces. 13th, Very flat double six-sided pyramid. 14th, Cube truncated on the edges. Crystal small. Surface rough, uneven, or streaked. Lustre splendent, and internally perfect adamantine. Cleavage octohedral, or parallel to the sides of an octohedron. Foliated structure. Fragments octohedral or tetrahedral. Semitransparent. Refracts single. Scratches all known minerals. Rather easily frangible. Streak grey. Sp. gr. 3·4 to 3·6. It consists of pure carbon, as we shall presently demonstrate. When rubbed, whether in the rough or polished state, it shows positive electricity; whereas rough quartz affords negative. It becomes phosphorescent on exposure to the sun or the electric spark, and shines with a fiery light. In its power of refracting light it is exceeded only by red lead ore, and orpiment. It reflects all the light falling on its posterior surface at an angle of incidence greater than 24° 13′, whence its great lustre is derived. Artificial gems reflect the half of this light. It occurs in imbedded grains and crystals in a sandstone in Brazil, which rests on chlorite and clay-slate. In India the *diamond bed* of clay is underneath beds of red or bluish-black clay: and also in alluvial tracts both in India and Brazil. For the mode of working diamond mines, and cutting and polishing diamonds, consult *Jameson's Mineralogy*, vol. i. p. 11.

The diamond is the most valued of all minerals. Dr. Wollaston has explained the cutting principle of glaziers' diamonds, with his accustomed sagacity, in the Phil. Trans. for 1816.

The weight, and consequently the value of diamonds, is estimated in carats, one of which is equal to four grains; and the price of one diamond, compared to that of another of equal colour, transparency, purity, form, &c. is as the squares of the respective weights. The average price of rough diamonds that are worth working, is about £.2 for the first carat. The value of a cut diamond being equal to that of a rough diamond of double weight, exclusive of the price of workmanship, the cost of a wrought diamond of

1 carat is £.8
2 do. is $2^2 \times$ £.8, = 32
3 do. is $3^2 \times$ £.8, = 72
4 do. is $4^2 \times$ £.8, = 128

100 do. is $100^2 \times$ £.8, = 80000.

This rule, however, is not extended to diamonds of more than 20 carats. The larger ones are disposed of at prices inferior to their value by that computation. The snow-white diamond is most highly prized by the jeweller. If transparent and pure, it is said to be of the first water.

The carat grain is different from the Troy grain. 156 carats make up the weight of one oz. Troy; or 612 diamond grains are contained in the Troy ounce.

From the high refractive power of the diamond, MM. Biot and Arago supposed that it might contain hydrogen. Sir H. Davy, from the action of potassium on it, and its non-conduction of electricity, suggested in his third Bakerian lecture that a minute portion of oxygen might exist in it; and in his new experiments on the fluoric compounds he threw out the idea, that it might be the carbonaceous principle, combined with some new, light, and subtle element, of the oxygenous and chlorine class.

This excellent chemist, during his residence at Florence in March 1814, made several experiments on the combustion of the diamond and of plumbago, by means of the great lens in the cabinet of natural history; the same instrument as that employed in the first trials on the action of the solar heat on the diamond, instituted in 1694 by Cosmo III. Grand Duke of Tuscany. He subsequently made a series of researches on the combustion of different kinds of charcoal at Rome. His mode of investigation was peculiarly elegant, and led to the most decisive results.

He found that diamond, when strongly ignited by the lens, in a thin capsule of platinum, perforated with many orifices, so as to admit a free circulation of air, continued to burn with a steady brilliant red light, visible in the brightest sunshine, after it was withdrawn from the focus. Some time after the diamonds were removed out of the focus, indeed, a wire of platina that attached them to the tray was fused, though their weight was only 1·84 grains. His apparatus consisted of clear glass globes of the capacity of from 14 to 40 cubic inches, having single apertures to which stop-cocks were attached. A small hollow cylinder of platinum was attached to one end of the stop-cock, and was mounted with the little perforated capsule for containing the diamond. When the experiment was to be made, the globe, containing the capsule and the substance to be burned, was exhausted by an excellent air-pump, and pure oxygen, from chlorate of potash, was then introduced. The change of volume in the gas after combustion was estimated by means of a fine tube connected with a stop-cock, adapted by a proper screw to the stop-cock of the globe, and the absorption was judged of by the quantity of mercury that entered the tube, which afforded a measure so exact, that no alteration however minute could be overlooked. He had previously satisfied himself that a quantity of moisture, less than 1-100th of a grain, is rendered evident by deposition on a polished surface of glass; for a piece of paper weighing one grain was introduced into a tube of about four cubic inches capacity, whose exterior was slightly heated by a candle. A dew was immediately perceptible on the inside of the glass, though the paper, when weighed in a balance turning with 1-100th of a grain, indicated no appreciable diminution.

The diamonds were always heated to redness before they were introduced into the capsule. During their combustion, the glass globe was kept cool by the application of water to that part of it immediately above the capsule, and where the heat was greatest.

From the results of his different experiments, conducted with the most unexceptionable precision, it is demonstrated, that diamond affords no other substance by its combustion than pure carbonic acid gas; and that the process is merely a solution of diamond in oxygen, without any change in the volume of the gas. It likewise appears, that in the combustion of the different kinds of charcoal, water is produced; and that from the diminution of the volume of the oxygen, there is every reason to believe that the water is formed by the combustion of hydrogen existing in strongly ignited charcoal. As the charcoal from oil of turpentine left no residuum, no other cause but the presence of hydrogen can be assigned for the diminution occasioned in the volume of the gas during its combustion.

The only chemical difference perceptible between diamond and the purest charcoal is, that the last contains a minute portion of hydrogen; but can a quantity of an element, less in some cases than 1-50,000th part of the weight of the substance, occasion so great a difference in physical and chemical characters? The opinion of Mr. Tennant, that the difference depends on crystallization, seems to be correct. Transparent solid bodies are in general non-conductors of electricity; and it is probable that the same corpuscular arrangements which give to matter the power of transmitting and polarizing light, are likewise connected with its relations to electricity. Thus water, the hydrates of the alkalis, and a number of other bodies which are conductors of electricity when fluid, become non-conductors in their crystallized form.

That charcoal is more inflammable than the diamond, may be explained from the looseness of its texture, and from the hydrogen it contains. But the diamond appears to burn in oxygen with as much facility as plumbago, so that at least one distinction supposed to exist between the diamond and common carbonaceous substances is done away by these researches. The power possessed by certain carbonaceous substances of absorbing gases, and separating colouring matters from fluids, is probably mechanical, and dependent on their porous organic structure; for it belongs in the highest degree to vegetable and animal charcoal, and it does not exist in plumbago, coak, or anthracite.

The nature of the chemical difference between the diamond and other carbonaceous substances may be demonstrated by igniting them in chlorine, when muriatic acid is produced from the latter, but not from the former.

The visible acid vapour is owing to the moisture present in the chlorine uniting to the dry muriatic gas. But charcoal, after being intensely ignited in chlorine, is not altered in its conducting power or colour. This circumstance is in favour of the opinion, that the minute quantity of hydrogen is not the cause of the great difference between the physical properties of the diamond and charcoal.

It does not appear that any sum exceeding one hundred and fifty thousand pounds has been given for a diamond.

DIASPORE. This rare mineral has been found in a mass consisting of slightly curvilinear laminæ of a shining pearly lustre, and greenish-grey colour; as also in cellular masses; composed of slender crystals of a pearly lustre. Brown externally, but perfectly transparent and colourless in thin laminæ. By the heat of a candle, it crackles and is *dispersed* in minute fragments, whence its name *Diaspore*. It scratches glass. Sp. grav. 3.43. It consists of, alumina 80, water 17, iron 0.3. *Vauquelin.* The brown variety consists, according to Mr. Children, of alumina 76.06, protoxide of iron 7.78, water 14.7, loss 1.46.

DICHROITE. See IOLITE.

DIGESTER. A strong and tight kettle of iron or copper, furnished with a valve of safety, in which bodies may be subjected to the vapour of water, alcohol, or ether, at a pressure above that of the atmosphere.

DIGESTER. The digester is an instrument invented by Mr. Papin about the beginning of the last century. It is a strong vessel of copper or iron, with a cover adapted to screw on with pieces of felt or paper interposed. A valve with a small aperture is made in the cover, the stopper of which valve may be more or less loaded, either by actual weights, or by pressure from an apparatus on the principle of the steelyard.

The purpose of this vessel is to prevent the loss of heat by evaporation. The solvent power of water when heated in this vessel is greatly increased.

DIGESTION. The slow action of a solvent upon any substance.

DIGESTION. The conversion of food into *chyme* in the stomach of animals, by the solvent power of the gastric juice. Some interesting researches have been lately made on this subject by Dr. Wilson Philip and Dr. Prout.

Phenomena, &c. of digestion in a rabbit.—A rabbit which had been kept without food for twelve hours was fed upon a mixture of bran and oats. About two hours afterwards it was killed, and examined immediately while still warm, when the following circumstances were noticed: The stomach was moderately distended, with a pulpy mass, which consisted of the food in a minute state of division, and so intimately mixed, that the different articles of which it was composed could be barely recognized. The digestive process, however, did not appear to have taken place equally throughout the mass, but seemed to be confined principally to the superficies, or where it was in contact with the stomach. The smell of this mass was peculiar, and difficult to be described. It might be denominated fatuous and disagreeable. On being wrapped up in a piece of linen, and subjected to moderate pressure, it yielded upwards of half a fluid ounce of an opaque reddish-brown fluid, which instantly reddened litmus paper very strongly. It instantly coagulated milk, and, moreover, seemed to possess the property of redissolving the curd, and converting it into a fluid, very similar to itself in appearance. It was not coagulated by heat or acids; and, in short, did not exhibit *any evidence of an albuminous principle.* On being evaporated to dryness, and burned, it yielded very copious traces of an alkaline muriate, with slight traces of an alkaline phosphate and sulphate; also of various earthy salts, as the sulphate, phosphate, and carbonate of lime.

"The first thing," says Dr. P. "which strikes the eye on inspecting the stomachs of rabbits which have lately eaten, is, that the new is never mixed with the old food. The former is always found in the centre surrounded on all sides by the old food, except that on the upper part between the new food and the smaller curvature of the stomach, there is sometimes little or no old food. If the old and the new food are of different kinds, and the animal be killed after taking the latter, unless a great length of time has elapsed after taking it, the line of separation is perfectly evident, so that the old may be removed without disturbing the new food.

"It appears that in proportion as the food is digested, it is moved along the great curvature, when the change in it is rendered more perfect, to the pyloric portion. The layer of food lying next the surface of the stomach is first digested. In proportion as this undergoes the proper change, it is moved on by the muscular action of the stomach, and that next in turn succeeds to undergo the same change. Thus a continual motion is going on; that part of the food which lies next the surface of the stomach passing towards the pylorus, and the more central parts approaching the surface."

Dr. Philip has remarked, that the great end of the stomach is the part most usually found acted upon by the digestive fluids after death.

The following phenomena were observed by Dr. Prout:—

Comparative examination of the contents of the duodena of two dogs, one of which had been fed on vegetable food, the other on animal food only. The chymous mass from vegetable food (principally bread) was composed of a semi-fluid, opaque, yellowish-white part, containing another portion of a similar colour, but firmer consistence, mixed with it. Its specific gravity was 1.056. It showed no traces of a free acid or alkali; but coagulated milk completely when assisted by a gentle heat.

That from animal food was more thick and viscid than that from vegetable food, and its colour was more inclined to red. Its sp. gr. was 1.022. It showed no traces of a free acid or alkali, nor did it coagulate milk even when assisted by the most favourable circumstances.

On being subjected to analysis, these two specimens were found to consist of

	Chyme from vegetable food.	Chyme from animal food.
Water, . .	86.5	80.0
Gastric principle, united with the alimentary matters, and apparently constituting the chyme, mixed with excrementitious matter,	6.0	15.8
Albuminous matter, partly consisting of fibrin, derived from the flesh on which the animal had been fed, .	—	1.3
Biliary principle, .	1.6	1.7
Vegetable gluten? .	5.0	—
Saline matters, .	0.7	0.7
Insoluble residuum, .	0.2	0.5
	100.0	100.0

Very similar phenomena were observed in other instances. But when the animal was opened at a longer period after feeding, Dr. Prout generally found much stronger evidences of albuminous matter, not only in the duodenum, but nearly throughout the whole of the small intestines. The quantity, however, was generally very minute in the ileum; and where it enters the cœcum, no traces of this principle could be perceived. See SANGUIFICATION.

Dr. Prout has lately shown that free, or at least unsaturated muriatic acid, in no small quantity exists in the stomachs of many animals during the digestive process. He has also uniformly found free muriatic acid in great abundance in the acid fluids ejected from the human stomach in severe cases of dyspepsia. *Phil. Trans. for* 1824. *Part* 1.

DIGESTIVE SALT. Muriate of potash.

DIGITALINE. The active principle of digitalis discovered by M. Royer. It was obtained by digesting a pound of the plant of commerce in ether, first cold, and then heated under pressure. The solution was filtered and evaporated, the residuum dissolved in water and filtered, the solution treated with hydrated oxide of lead, the whole evaporated and digested in ether, which dissolved out the active principle. On evaporation it appeared as a brown pasty substance, slowly restoring the blue colour of reddened litmus paper, very bitter and deliquescent. It crystallizes with difficulty. A grain of it, dissolved in 180 grains of water, being injected into the abdomen of a rabbit, killed the animal speedily without agitation or pain, which is the more remarkable as the rabbit is convulsed with great facility. *Bibliotheque Universelle*, xxvi. 102.

DIOPSIDE. A sub-species of oblique edged augite. Its colour is greenish-white. It occurs massive, disseminated and crystallized: 1. In low oblique four-sided prisms. 2. The same, truncated on the acute lateral edges, bevelled on the obtuse edges, and the edge of the bevelment truncated. 3. Eight-sided prisms. The broader lateral planes are deeply longitudinally streaked, the others are smooth. Lustre shining and pearly. Fracture uneven. Translucent. As hard as augite. Sp. gr. 3.3. It melts with difficulty before the blowpipe. It consists of 57.5 silica, 18.25 magnesia, 16.5 lime, 6 iron and manganese.—*Laugier*. It is found in the hill Ciarmetta in Piedmont; also in the black rock at Musa, near the town of Ali, in veins along with epidote or pistacite, and hyacinth-red garnets. It is the Alalite and Mussite of Bonvoisin.

DIOPTASE. Emerald copper-ore.

DIPPEL'S Animal Oil. An oily matter obtained in the igneous decomposition of horns in a retort. Rectified, it becomes colourless, aromatic, and as light and volatile as ether. It changes syrup of violets to a green, from its holding a little ammonia in solution.

DIPYRE. Schmelzstein.

This mineral is distinguished by two characters; it is fusible with intumescence by the blowpipe, and it emits on coals a faint phosphorescence. It is found in small prisms, united in bundles, of a greyish or reddish-white. These crystals are splendent, hard enough to scratch glass; their longitudinal fracture is lamellar, and their cross fracture conchoidal. Its sp. gr. is 2.63. The primitive form appears to be the regular six-sided prism. It consists of 60 silica, 24 alumina, 10 lime, 2 water, and 4 loss.—*Vauquelin.* It occurs in a white or reddish steatite, mingled with sulphuret of iron, on the right bank of the torrent of Mauléon in the western Pyrenees.

DISTILLATION. The vaporization and subsequent condensation of a liquid, by means of an alembic, or still and refrigeratory, or of a retort and a receiver. The old distinctions of *distillatio per latus*, *per ascensum*, and *per descensum*, are now discarded.

Under LABORATORY, a drawing and description of a large still of an ingenious construction is given. The late celebrated Mr. Watt having ascertained that liquids boiled *in vacuo* at much lower temperatures than under the pressure of the atmosphere, applied this fact to distillation; but he seems, according to Dr. Black's report of the experiment, to have found no economy of fuel in this elegant process; for the latent heat of the vapour raised *in vacuo*, appeared to be considerably greater than that raised in ordinary circumstances. Mr. Henry Tritton has lately contrived a very simple apparatus for performing this operation *in vacuo;* and though no saving of fuel should be made, yet superior flavour may be secured to the distilled spirits and essential oils, in consequence of the moderation of the heat. The still is of the common form; but, instead of being placed immediately over a fire, it is immersed in a vessel containing hot water. The pipe from the capital bends down, and terminates in a cylinder or barrel of metal, plunged in a cistern of cold liquid. From the bottom of this barrel a pipe proceeds to another of somewhat larger dimensions, which is surrounded with cold water, and furnished at its top with an exhausting syringe.

The pipe from the bottom of the still, for emptying it, and that from the bottom of each barrel, are provided with stop-cocks. Hence, on exhausting the air, the liquid will distil rapidly, when the body of the alembic is surrounded with boiling water. When it is wished to withdraw a portion of the distilled liquor, the stop-cock at the bottom of the first receiver is shut, so that on opening that at the second, in order to empty it, the vacuum is maintained in the still. It is evident that the first receiver may be surrounded with a portion of the liquid to be distilled, as I have already explained in treating of alcohol. By this means the utmost economy of fuel may be observed.

The term *distillation* is often applied in this country to the whole process of converting malt or other saccharine matter into spirits or alcohol.

In making malt whisky, one part of bruised malt, with from four to nine parts of barley-meal, and a proportion of seeds of oats, corresponding to that of the raw grain, is infused in a mash-tun of cast iron, with from 12 to 13 wine gallons of water, at 150° Fahr. for every bushel of the mixed farinaceous matter. The agitation then given by manual labour or machinery to break down and equally diffuse the lumps of meal constitutes the process of *mashing.* This operation continues two hours or upwards, according to the proportion of unmalted barley; during which the temperature is kept up by the affusion of seven or eight additional gallons of water, a few degrees under the boiling temperature. The infusion, termed *wort*, having become progressively sweeter, is allowed to settle for two hours, and is run off from the top, to the amount of about one-third the bulk of water employed. About eight gallons of more water, a little under 200° F. are now admitted to the residuum, *infused* for nearly half an hour with agitation, and then left to subside for an hour and a half, when it is drawn off. Sometimes a third affusion of boiling water, equal to the first quantity, is made, and this infusion is generally reserved to be poured on new *farina;* or it is concentrated by boiling, and added to the former liquors. In Scotland, the distiller is supposed by law to extract per cent. 14 gallons of spirits, sp. gr. 0.91917, or 1 to 10 over proof, and must pay duty accordingly. Hence, his wort must have at least the strength of $55\frac{1}{2}$ pounds of saccharine matter per barrel, previous to letting it down into the fermenting tun; and the law does not permit it to be stronger than 75 pounds. Every gallon of the above spirits contains 4.6 pounds of alcohol, sp. gr. 0.825, and requires for its production the complete decomposition of twice 4.6 pounds of sugar = 9.2 pounds. But since we can never count on decomposing above four-fifths of the saccharine matter of wort, we must add one-fifth to 9.2 pounds, when we shall have $11\frac{1}{2}$ pounds for the weight of saccharine matter, equivalent in practice to one gallon of the legal spirits. Hence, the distiller is compelled to raise the strength of his wort up to nearly 70 pounds per barrel, as indicated by his saccharometer. This concentration is to be regretted, as it materially injures the flavour of the spirit. The thinner worts of the Dutch give a decided superiority to their alcohols. At 62 pounds per barrel, we should have about 12 per cent. of spirits of the legal standard.

To prevent acetification, it is necessary to cool the worts down to the proper fermenting temperature of 70° or 65° as rapidly as possible. Hence, they are pumped immediately from the mash-tun into extensive wooden troughs, two or three inches deep, exposed in open sheds to the cool air; or they are made to traverse the convolutions of a pipe immersed in cold water. The wort being now run into the fermenting tun, yeast is introduced and added in nearly equal successive portions during three days, amounting in all to about one gallon for every two bushels of farinaceous matter. The temperature rises in three or four days to its maximum of 80°; and at the end of 10 or 12 days the fermentation is completed, the tuns being closed up during the last half of the period. The distillers do not collect the yeast from their fermenting tuns, but allow it to fall down, on the supposition, that it enhances the quantity of alcohol.

The specific gravity of the liquid has now probably sunk from 1·060, that of wort, equivalent to about 56 pounds per barrel, to 1·005, or 1·000; and consists of alcohol mixed with undecomposed saccharine and farinaceous matter. The larger the proportion of alcohol, the more sugar will be preserved unchanged; and hence the impolicy of restrictive laws on distillation.

Some years ago, when the manufacturer paid a duty for the season, merely according to the measurement of his still, it was his interest to work it off with the utmost possible speed. Hence the form of still and furnace described under LABORATORY, was contrived by some ingenious Scotch distillers, by which means they could work off in less than four minutes, and recharge, an 80 gallon still; an operation which had a few years before lasted several days, and which the vigilant framers of the law, after recent investigation, deemed possible only in eight minutes. The waste of fuel was however great. The duties being now levied on the product of spirits, the above contest against time no longer exists. It has been supposed, but I think on insufficient ground, that quick distillation injures the flavour of spirits. This I believe to depend almost entirely on the mode of conducting the previous fermentation.

In distilling off the spirit from the fermented wort or wash, a hydrometer is used to ascertain its progressive diminution of strength; and when it acquires a certain weakness, the process is stopped by opening the stop-cock of the pipe which issues from the bottom of the still, and the spent wash is removed. There is generally introduced into the still a bit of soap, whose oily principle spreading on the surface of the boiling liquor, breaks the large bubbles, and of course checks the tendency to froth up. The spirits of the first distillation, called in Scotland *low wines*, are about 0 975 sp. gr., and contain nearly 20 per cent. of alcohol of 0.825. Redistillation of the *low wines*, or *doubling*, gives at first the fiery spirit called first-shot, milky and crude, from the presence of a little oil. This portion is returned into the low wines. What flows next is clear spirit, and is received in one vessel, till its density diminish to a certain degree. The remaining spirituous liquor, called *faints*, is mixed with *low wines*, and subjected to another distillation.

The manufacturer was formerly hindered by law from sending out of his distillery stronger spirits than 1 to 10 over hydrometer proof, equivalent to sp. gr. 0.90917; or weaker spirits than 1 in 6 under proof, whose sp. gr. is 0.9385.

The following is said to be the Dutch mode of making Geneva: —

One cwt. of barley malt and two cwts. of rye meal are mashed with 460 gallons of water, heated to 162° F. After the *farinæ* have been infused for a sufficient time, cold water is added, till the wort becomes equivalent to 45 pounds of saccharine matter per barrel. Into a vessel of 500 gallons capacity the wort is now put at the temperature of 80°, with half a gallon of yeast. The fermentation instantly begins, and is finished in 48 hours, during which the heat rises to 90°. The wash, not reduced lower than 12 or 15 pounds per barrel, is put into the still along with the grains. Three distillations are required; and at the last a few juniper berries and hops are introduced, to communicate flavour. The attenuation of 45 pounds in the wort, to only 15 in the wash, shows that the fermentation is here very imperfect and uneconomical; as indeed we might infer from the small proportion of yeast, and the precipitancy of the process of fermentation. On the other hand, the very large proportion of porter yeast in a corrupting state, used by the Scotch distillers, cannot fail to injure the flavour of their spirits.

Rum is obtained from the fermentation of the coarsest sugar and molasses in the West Indies, dissolved in water in the proportion of nearly a pound to the gallon. The yeast is procured chiefly from the rum *wort*. The preceding details give sufficient instruction for the conduct of this modification of the process

Sykes' hydrometer is now universally used in the collection of the spirit revenue in Great Britain. It consists, first, of a flat stem, 3.4 inches long, which is divided on both sides into 11 equal parts, each of which is subdivided into two, the scale being numbered from 0 to 11. This stem is soldered into a brass ball 1.6 inch in diameter, into the under part of which is fixed a small conical stem 1.13 inch long, at whose end is a pear-shaped loaded bulb, half an inch in diameter. The whole instrument, which is made of brass, is 6.7 inches long. The instrument is accompanied with 8 circular weights, numbered 10, 20, 30, 40, 50, 60, 70, 80, and another weight of the form of a parallelopiped. Each of the circular weights is cut into its centre, so that it can be placed on the inferior conical stem, and slid down to the bulb; but in consequence of the enlargement of the cone, they cannot slip off at the bottom, but must be drawn up to the thin part for this purpose The square weight of the form of a parallelopiped has a square notch in one of its sides, by which it can be placed on the summit of the stem. In using this instrument, it is immersed in the spirit, and pressed down by the hand to 0, till the whole divided part of the stem be wet. The force of the hand required to sink it will be a guide in selecting the proper weight. Having taken one of the circular weights, which is necessary for this purpose, it is slipped on the conical stem. The instrument is again immersed and pressed down as before to 0, and is then allowed to rise and settle at any point of the scale. The eye is then brought to the level of the surface of the spirit, and the part of the stem cut by the surface, *as seen from below*, is marked. The number thus indicated by the stem is added to the number of the weight employed, and with this sum at the side, and the temperature of the spirits at the top, the strength *per cent.* is found in a table of 6 quarto pages. "The strength is expressed in numbers denoting the excess or deficiency *per cent.* of proof spirit in any sample, and the number itself (having its decimal point removed two places to the left) becomes a factor, whereby the gauged content of a cask or vessel of such spirit being multiplied, and the product being added to the gauged content, if over proof, or deducted from it if under proof, the result will be the actual quantity of proof spirit contained in such cask or vessel." See ALCOHOL.

DISTHENE. See CYANITE.

DISTINCT CONCRETIONS. A term in MINERALOGY.

DOCIMASTIC ART. This name is given to the art of assaying. See ASSAY, BLOWPIPE, ANALYSIS, and the several metals.

DOLERITE. When volcanic masses are composed of grains distinct from each other, and contain besides felspar, much pyroxene, black oxide of iron, amphibole, &c. they are called by the French geologists, Dolerite. They may be regarded as modifications of the basalt of the British, passing into the grünstein of Werner.—*See D'Aubuisson Traité de Geognosie*, ii. 558, *note*.

DOLOMITE. Of this calcareo-magnesian carbonate, we have three sub-species.

1. Dolomite, of which there are two kinds.

§ 1st, *Granular dolomite.*

White granular. It occurs massive, and in fine granular distinct concretions, loosely aggregated. Lustre glimmering and pearly. Fracture in the large, imperfect slaty. Faintly translucent. As hard as fluor. Brittle. Sp. gr. 2.83. It effervesces feebly with acids. Phosphorescent on heated iron, or by friction. Its constituents are, 46.5 carbonate of magnesia, 52.08 carbonate of lime, 0.25 oxide of manganese, and 0.5 oxide of iron. *Klaproth.* Beds of dolomite, containing tremolite, occur in the island of Iona, in the mountain group of St. Gothard, in the Apennines, and in Carinthia. A beautiful white variety, used by ancient sculptors, is found in the Isle of Tenedos. *Jameson.*

The *flexible* variety was first noticed in the Borghese palace at Rome; but the other varieties of dolomite, and also common granular limestone, may be rendered flexible, by exposing them in thin and long slabs to a heat of 480° Fahr. for 6 hours.

§ 2d, *Brown Dolomite*, or Magnesian limestone of Tennant.

Colour, yellowish-grey and yellowish-brown. Massive, and in minute granular concretions. Lustre, internally glistening. Fracture splintery. Translucent on the edges. Harder than calcareous spar. Brittle. Sp. gr. of crystals, 2.8. It dissolves slowly, and with feeble effervescence; and when calcined, it is long in reabsorbing carbonic acid from the air. Its constituents are, lime 29.5, magnesia 20.3, carbonic acid 47.2, alumina and iron 0.8. *Tennant.* In the north of England it occurs in beds of considerable thickness, and great extent, resting on the Newcastle coal formation. In the Isle of Man, it occurs in a limestone which rests on grey-wacke. It occurs in trap-rocks in Fifeshire. When laid on land after being calcined, it prevents vegetation, unless the quantity be small.

To the preceding variety we must refer a *flexible dolomite* found near Tinmouth Castle. It is yellowish-grey, passing into cream-yellow. Massive. Dull. Fracture earthy. Opaque. Yields readily to the knife. In thin plates, very flexible. Sp. gr. 2·54; but the stone is porous. It dissolves in acids as readily as common carbonate of lime. Its constituents are said to be 62 carbonate of lime, and 36 carbonate of magnesia. When made moderately dry, it loses its flexibility; but when either very moist or very dry, it is very flexible.

2d, *Columnar Dolomite*. Colour pale greyish-white. Massive, and in thin prismatic concretions. Cleavage imperfect. Fracture uneven. Lustre vitreous, inclining to pearly. Breaks into acicular fragments. Feebly translucent. Brittle. Sp. gr. 2·76. Its constituents are, 51 carbonate of lime, 47 carbonate of magnesia, 1 carbonated hydrate of iron. It occurs in serpentine in Russia.

3d, *Compact Dolomite*, or Gurhofite. Colour snow-white. Massive. Dull. Fracture flat conchoidal. Slightly translucent on the edges. Semi-hard. Difficultly frangible. Sp. gr. 2.76. When pulverized, it dissolves with effervescence in hot nitric acid. It consists of 70.5 carbonate of lime, and 29.5 carbonate of magnesia. It occurs in veins in serpentine rocks, near Gurhoff, in Lower Austria.

DOMITE. This mineral is white. Feels and looks like sandy chalk. It is considered by some to be decomposed felspar. It is found in the Puy de Dome in Auvergne.

DRACO-MITIGATUS. Calomel. See MERCURY.

DRAGON'S BLOOD. A brittle, dark-red coloured resin, imported from the East Indies, the product of *pterocarpus draco*, and *dracæna draco.* It is insoluble in water, but soluble in a great measure in alcohol. The solution imparts a beautiful red stain to hot marble. It dissolves in oils. It contains a little benzoic acid.

DRAWING SLATE. Black chalk. Colour greyish-black. Massive. Lustre of the principal fracture, glimmering; of the cross fracture, dull. Fracture of the former slaty, of the latter, fine earthy. Opaque. It writes. Streak same colour, and glistening. Very soft. Sectile. Easily frangible. It adheres slightly to the tongue. Feels fine, but meagre. Sp. gr. 2.11. It is infusible. Its constituents are, silica 64.06; alumina 11, carbon 11, water 7.2, iron 2.75. It occurs in beds, in primitive and transition clay-slate, also in secondary formations. It is found in the coal formation of Scotland, and in most countries. It is used in crayon-painting. The trace of bituminous shale is brownish and irregular; that of black chalk is regular and black. The best kind is found in Spain, Italy, and France.

DUCTILITY. That property or texture of bodies, which renders it practicable to draw them out in length, while their thickness is diminished, without any actual fracture of their parts. This term is almost exclusively applied to metals.

Most authors confound the words malleability, laminability, and ductility, together, and use them in a loose indiscriminate way; but they are very different. Malleability is the property of a body which enlarges one or two of its three dimensions, by a blow or pressure very suddenly applied. Laminability belongs to bodies extensible in dimension by a gradually applied pressure: and ductility is properly to be attributed to such bodies as can be rendered longer and thinner by drawing them through a hole of less area than the transverse section of the body so drawn.

DYEING. The art of dyeing consists in fixing upon cloths of various kinds any colour which may be required, in such a manner as that they shall not be easily altered by those agents to which the cloth will most probably be exposed.

As there can be no cause by which any colouring matter can adhere to any cloth, except an attraction subsisting between the two substances, it must follow, that there will be few tingeing matters capable of indelibly or strongly attaching themselves by simple application.

Dyeing is therefore a chemical art.

The most remarkable general fact in the art of dyeing consists in the different degrees of facility with which animal and vegetable substances attract and retain colouring matter, or rather the degree of facility with which the dyer finds he can tinge them with any intended colour. The chief materials of stuff to be dyed are wool, silk, cotton, and linen, of which the former two are more easily dyed than the latter. This has been usually attributed to their greater attraction to the tingeing matter.

Wool is naturally so much disposed to combine with colouring matter, that it requires but little preparation for the immediate processes of dyeing; nothing more being required than to cleanse it, by scouring, from a fatty substance, called the yolk, which is contained in the fleece. For this purpose an alkaline liquor is necessary; but as alkalis injure the texture of the wool, a very weak solution may be used. For if more alkali were present than is sufficient to convert the yolk into soap, it would attack the wool itself. Putrid urine is therefore generally used, as being cheap, and containing a volatile alkali, which, uniting with the grease, renders it soluble in water.

Silk, when taken from the cocoon, is covered with a kind of varnish, which, because it does not easily yield either to water or alcohol, is usually said to be soluble in neither. It is therefore usual to boil the silk with an alkali, to disengage this matter. Much care is necessary in this operation, because the silk itself is easily corroded or discoloured. Fine soap is commonly used, but even this is said to be detrimental; and the white China silk, which is supposed to be prepared without soap, has a lustre superior to that of Europe. Silk loses about one-fourth of its weight by being deprived of its varnish. See BLEACHING.

The intention of the previous preparations seems to be of two kinds. The first, to render the stuff or material to be dyed as clear as possible, in order that the aqueous fluid to be afterward applied may be imbibed, and its contents adhere to the minute internal surfaces. The second is, that the stuff may be rendered whiter and more capable of reflecting the light, and consequently enabling the colouring matter to exhibit more brilliant tints.

Some of the preparations, however, though considered merely as preparative, do really constitute part of the dyeing processes themselves. In many instances a material is applied to the stuff, to which it adheres; and when another suitable material is applied, the result is some colour desired. Thus we might dye a piece of cotton black, by immersing it in ink; but the colour would be neither good nor durable, because the particles of precipitated matter formed of the oxide of iron and acid of galls, are already concreted in masses too gross either to enter the cotton, or to adhere to it with any considerable degree of strength. But if the cotton be soaked in an infusion of galls, then dried, and afterward immersed in a solution of sulphate of iron, (or other ferruginous salt), the acid of galls being every-where diffused through the body of the cotton, will receive the particles of oxide of iron, at the very instant of their transition from the fluid, or dissolved to the precipitated or solid state; by which means a perfect covering of the black inky matter will be applied in close contact with the surface of the most minute fibres of the cotton. This dye will therefore not only be more intense, but likewise more adherent and durable.

The French dyers, and after them the English, have given the name of *mordant* to those substances which are previously applied to piece goods, in order that they may afterward take a required tinge or dye.

It is evident, that if the mordant be universally applied over the whole of a piece of goods, and this be afterward immersed in the dye, it will receive a tinge over all its surface; but if it be applied only in parts, the dye will strike in those parts only. The former process constitutes the art of dyeing, properly so called; and the latter, the art of printing woollens, cottons, or linen, called calico-printing.

In the art of printing piece goods, the mordant is usually mixed with gum or starch, and applied by means of blocks or wooden engravings in relief, or from copper plates, and the colours are brought out by immersion in vessels filled with suitable compositions. Dyers call the latter fluid the bath. The art of printing affords many processes, in which the effect of mordants, both simple and compound, is exhibited. The following is taken from Berthollet.

The mordant employed for linens, intended to receive different shades of red, is prepared by dissolving in eight pounds of hot water, three pounds of alum and one pound of acetate of lead, to which two ounces of potash, and afterward two ounces of powdered chalk, are added.

In this mixture, the sulphuric acid combines with the lead of the acetate and falls down, because insoluble, while the argillaceous earth of the alum unites with the acetic acid disengaged from the acetate of lead. The mordant therefore consists of an argillaceous acetic salt, and the small quantities of alkali and chalk serve to neutralize any disengaged acid which might be contained in the liquid.

Several advantages are obtained by thus changing the acid of the alum. First, the argillaceous earth is more easily disengaged from the acetic acid, in the subsequent processes, than it would have been from the sulphuric. Secondly, this weak acid does less harm when it comes to be disengaged by depriving it of its earth. And thirdly, the acetate of alumina, not being crystallizable like the sulphate, does not separate or curdle by drying on the face of the blocks for printing, when it is mixed with gum or starch.

When the design has been impressed by transferring the mordant from the face of the wooden blocks to the cloth, it is then put into a bath of madder, with proper attention that the whole shall be equally exposed to this fluid. Here the piece becomes of a red colour, but deeper in those places where the mordant was applied. For some of the argillaceous earth had before quitted the acetic acid, to combine with the cloth; and this serves as an intermedium to fix the colouring matter of the madder, in the same manner as the acid of galls, in the former instance, fixed the particles of oxide of iron. With the piece in this state, the calico-printer has only therefore to avail himself of the difference between a fixed and a fugitive colour. He therefore boils the piece with bran, and spreads it on the grass. The fecula of the bran takes up part of the colour, and the action of the sun and air renders more of it combinable with the same substance.

In other cases the elective attraction of the stuff to be dyed has a more marked agency. A very common mordant for woollens is made by dissolving alum and tartar together; neither of which is decomposed, but may be recovered by crystallization upon evaporating the liquor. Wool is found to be capable of decomposing a solution of alum, and combining with its earth; but it seems as if the presence of disengaged sulphuric acid served to injure the wool, which is rendered harsh by this method of treatment, though cottons and linens are not, which have less attraction for the earth. Wool also decomposes the alum, in a mixture of alum and tartar; but in this case there can be no disengagement of sulphuric acid, as it is immediately neutralized by the alkali of the tartar.

Metallic oxides have so great an attraction for many colouring substances, that they quit the acids in which they were dissolved, and are precipitated in combination with them. These oxides are also found by experiment to be strongly disposed to combine with animal substances; whence in many instances they serve as mordants, or the medium of union between the colouring particles and animal bodies.

The colours which the compounds of metallic oxides and colouring particles assume, then, are the product of the colour peculiar to the colouring particles, and of that peculiar to the metallic oxide.

The following are the dye-stuffs used by the calico-printers for producing fast colours. The mordants are thickened with gum, or calcined starch, and applied with the block, roller, plates, or pencil.

1. *Black.* The cloth is impregnated with acetate of iron (iron liquor), and dyed in a bath of madder and logwood.

2. *Purple.* The preceding mordant of iron, diluted; with the same dyeing bath.

3. *Crimson.* The mordant for purple, united with a portion of acetate of alumina, or red mordant, and the above bath.

4. *Red.* Acetate of alumina is the mordant, (see ALUMINA), and madder is the dye-stuff.

5. *Pale red* of different shades. The preceding mordant diluted with water, and a weak madder bath.

6. *Brown* or *Pompadour.* A mixed mordant, containing a somewhat larger proportion of the red than of the black; and the dye of madder.

7. *Orange*. The red mordant; and a bath first of madder, and then of quercitron.

8. *Yellow*. A strong red mordant; and the quercitron bath, whose temperature should be considerably under the boiling point of water.

9. *Blue*. Indigo, rendered soluble and greenish-yellow coloured, by potash and orpiment. It recovers its blue colour by exposure to air, and thereby also fixes firmly on the cloth. An indigo vat is also made, with that blue substance diffused in water with quicklime and copperas. These substances are supposed to deoxidize indigo, and at the same time to render it soluble.

Golden-dye. The cloth is immersed alternately in a solution of copperas and lime water. The protoxide of iron precipitated on the fibre, soon passes, by absorption of atmospherical oxygen, into the golden-coloured deutoxide.

Buff. The preceding substances, in a more dilute state.

Blue vat, in which white spots are left on a blue ground of cloth, is made, by applying to these points a paste composed of a solution of sulphate of copper and pipe-clay; and after they are dried, immersing it stretched on frames, for a definite number of minutes, in the yellowish-green vat, of 1 part of indigo, 2 of copperas, and 2 of lime, with water.

Green. Cloth dyed blue, and well washed, is imbued with the aluminous acetate, dried, and subjected to the quercitron bath.

In the above cases, the cloth, after receiving the mordant paste, is dried, and put through a mixture of cow-dung and warm water. It is then put into the dyeing vat or copper.

Fugitive Colours.

All the above colours are given by making decoctions of the different colouring woods; and receive the slight degree of fixity they possess, as well as great brilliancy, in consequence of their combination or admixture with the nitro-muriate of tin.

1. *Red* is frequently made from Brazil and Peachwood.

2. *Black*. A strong extract of galls, and deuto-nitrate of iron.

3. *Purple*. Extract of logwood and the deuto-nitrate.

4. *Yellow*. Extract of quercitron bark, or French berries, and the tin solution.

5. *Blue*. Prussian blue and solution of tin.

Fugitive colours are thickened with gum-tragacanth, which leaves the cloth in a softer state than gum-senegal; the goods being sometimes sent to market without being washed.

For the modes of using the different articles used in dyeing, see them under their respective names in the order of the alphabet.

DYSODILE or DUSODILE. A mineral found in masses of a greenish-grey, or of a yellow colour. Extremely fragile, emitting the argillaceous odour when breathed on. Sp. grav. 1·46. It burns with a considerable flame and smoke, and an almost insupportably fœtid odour, with a crackling noise. In water it becomes translucent and flexible. It occurs at Melili near Syracuse: in a thin bed, between strata of secondary limestone.

E

EAGLE-STONE. A clay ironstone.

EARTHENWARE. See POTTERY.

EARTHS. Twenty years ago, few substances seemed more likely to retain a permanent place in chemical arrangements, than the solid and refractory earths, which compose the crust of the globe. Analysis had shown, that the various stony or pulverulent masses, which form our mountains, valleys, and plains, might be considered as resulting from the combination or intermixture, in various numbers and proportions, of nine primitive earths, to which the following names were given:

1. Barytes. 2. Strontites. 3. Lime. 4. Magnesia. 5. Alumina, or clay. 6. Silica. 7. Glucina. 8. Zirconia. 9. Yttria.

Alkalis, acids, metallic ores, and native metals, were supposed to be of an entirely dissimilar constitution.

The brilliant discovery by Sir H. Davy in 1808, of the metallic bases of potash, soda, barytes, strontites, and lime, subverted the ancient ideas regarding the earths, and taught us to regard them as all belonging, by most probable analogies, to the metallic class. According to an ingenious suggestion of Mr. Smithson, silica, however, ought to be ranked with acids, since it has the power, in native mineral compounds, of neutralizing the alkaline earths, as well as the common metallic oxides. But as this property is also possessed by many metallic oxides, it can afford no evidence against the metallic nature of the siliceous basis. Alumina, by the experiments of Ehrman, may be made to saturate lime, producing a glass; and the triple compounds of magnesia, alumina, and lime, are perfectly neutral in porcelain. We might therefore refer alumina, as well as silica, to the same class with the oxides of antimony, arsenic, chromium, columbium, molybdenum, titanium, and tungsten. Alumina, however, bears to silica the same relation that oxide of antimony does to that of arsenic; the antecedent pair acting the part of bases, while the consequent pair act only as acids. The compound of the fluoric principle with silica is of too mysterious a nature to be employed in this discussion. The almost universal function which silica enjoys, of saturating the alkaline oxides in the native earthy minerals, is exhibited, in a very striking manner in Mr. Allan's valuable SYNOPTIC TABLES. From his fifth to his fifteenth table of analyses, the column of silica is always complete, whatever deficiency or variation may occur in the columns of the earthy *bases*. At least, only a very few exceptions need be made for the oriental gems, which consist of strongly aggregated alumina.

We shall enter at present into no further discussion concerning their place in a systematic arrangement. Whatever may be the revolutions of chemical nomenclature, mankind will never cease to consider as EARTHS those solid bodies composing the mineral strata, which are incombustible, colourless, not convertible into metals by all the ordinary methods of reduction, or when reduced by scientific refinements possessing but an evanescent metallic existence, and which either alone, or at least when combined with carbonic acid, are insipid and insoluble in water.

EAU DE LUCE consists chiefly of the essential oil of amber and the volatile alkali.

ECHINI. Calcareous putrefactions of the echinus, or sea-hedgehog.

EDINGTONITE. A new mineral. It occurs in crystals, the largest about two lines in diameter, implanted upon crystallized Thomsonite, in the Kilpatrick-hills, near Glasgow. It is accompanied by calcareous spar, and a curious variety of harmstome. The crystals of the edingtonite resemble greatly certain varieties of prennite and felspar. *Haidinger in Edinburgh Journal of Science, for October*, 1825.

EFFERVESCENCE is the commotion produced in fluids by some part of the mass suddenly taking the elastic form, and escaping in numerous bubbles.

EFFLORESCENCE is the effect which takes place when bodies spontaneously become converted into a dry powder. It is almost always occasioned by the loss of the water of crystallization in saline bodies.

EGERAN. A sub-species of pyramidal garnet. Colour, reddish-brown. Massive, sometimes crystallized in rectangular four-sided prisms, with cylindrical convex lateral planes. The prisms are long, and deeply longitudinally streaked. Shining, vitreous. Cleavage twofold. Fracture uneven. Feebly translucent on the edges. Scratches felspar. Brittle. Sp. gr. 3·294. It melts into a black scoria. It occurs in a bed of felspar and hornblende, at Haslan, near Eger in Bohemia.

EGGS. The eggs of hens, and of birds in general, are composed of several distinct substances. 1. The shell or external coating, which is composed of carbonate of lime ·72, phosphate of lime ·2, gelatine ·3. The remaining ·23 are perhaps water. 2. A thin white and strong membrane, possessing the usual characters of animal substances. 3. The white of the egg, for which see ALBUMEN. 4. The yolk, which appears to consist of an oil of the nature of fat oils, united with a portion of serous matter, sufficient to render it diffusible in cold water, in the form of an emulsion, and concrescible by heat. Yolk of egg is used as the medium for rendering resins and oils diffusible in water.

EISENRAHM. Red and brown; the scaly iron ore, and scaly manganese ore.

ELAIN. The oily principle of solid fats, so named by its discoverer, M. Chevreul. Chevreul dissolves the tallow in very pure hot alcohol, separates the *stearin* by crystallization, and then procures the *elaïn* by evaporation of the spirit. But M. Braconnot has adopted a simpler, and probably a more exact method. By squeezing tallow between the folds of porous paper, the *elaïn* soaks into it, while the stearin remains. The paper being then soaked in water, and pressed, yields up its oily impregnation. Elaïn has very much the appearance and properties of vegetable oil. It is liquid at the temperature of 60°. Its smell and colour are derived from the solid fats from which it is extracted.

Human elaïn is yellow, without odour. Specific gravity 0·913.

Elaïn of sheep; colourless, a faint smell. Sp. gr. 0·915.

Elaïn of ox; colourless, and almost without odour. Sp. gr. 0·915.

Elaïn of hog; do. do. 0·915.

Elaïn of jaguar; lemon colour, odorous, 0·914.

Elaïn of goose; light lemon colour, little odour. 0·929.

Solubility in alcohol of sp. gr. 0·7952.

Human elaïn; 11·1 gr. by 9. gr. at the boiling point.

Elaïn of sheep; 3·79 gr. by 3 gr. at do.

Elaïn of ox; 5·8 gr. by 4·7 gr. at do.

Elaïn of hog; 11·1 gr. by 9·0 gr. at do.

Elaïn of jaguar; 3·35 gr. by 2·71 gr. at do.

Elaïn of goose; 11·1 gr. by 9·0 gr. at do.

Elaïn of the fat of ox, extracted by alcohol, yields, by the action of potash,

Of saponified fat,	92·6 parts.
Of soluble matter,	7·4

Those of the other fats yield,

Of saponified fat,	89
Of soluble matter,	11

In M. Chevreul's 7th memoir on fats, published in the 7th vol. of the *Ann. de Chimie et Phys.*, he gives the following as the composition of the oleates from spermaceti:—

Oleic acid,	100
Barytes,	31·24
Strontian,	23·18
Oxide of lead,	160·00

If we suppose the last a suboleate, the equivalent of this oleic acid will be 28. The oil or oleic acid of the delphinus globiceps is remarkably soluble in cold alcohol, 100 parts of which of sp. gr. 0·795, at 68°, dissolve 123 of the oil. When that oil is freed by cold from a crystallizable matter, 100 parts of alcohol, sp. gr. 0·820, dissolve 149·4 of oil at the atmospheric temperature. It was slightly acid by the test of litmus, which he ascribes to the presence of an aqueous fluid. As stearine is saponified by cold strong alkaline solutions, while elaïn is not, these two substances may be separated, by agitating a concentrated solution of caustic soda in contact with them. The mixture must be then slightly heated, to separate the elaïn from the soap of stearine. It is then thrown on a filter-cloth, and finally, the elaïn is separated from the excess of alkaline solution by decantation. This process is successful with all oils, except those which are rancid, or have been altered by fire. The elaïn is perfectly identical with that obtained by the processes of MM. Chevreul and Braconnot. *Pictet, Ann. de Chim.* xxii. See Fat.

ELAOLITE. A sub-species of pyramidal felspar. Colours, duck-brown inclining to green, and flesh-red inclining to grey or brown. Massive, and in granular concretions. Lustre shining and resinous. Fracture imperfect conchoidal. Faintly translucent. Hardness as felspar. Easily frangible. Sp. gr. 2·6. Its powder forms a jelly with acids. Before the blowpipe, it melts into a milk-white enamel. Its constituents are 46·5 silica, 30·25 alumina, 0·75 lime, 18 potash, 1 oxide of iron, and 2 water. *Klaproth.* The blue is found at Laurwig, and the red at Stavern and Friedrickswarm, both in the rock named *zircon syenite*. The pale blue has an opalescence, like the cat's-eye, which occasions it to be cut into small ornaments. It is called *fettstein* by Werner, from its resinous nature.—*Jameson.*

ELASTIC BITUMEN. See Caoutchouc, Mineral.

ELECAMPANE. From the root of the *inula hellenium*, or elecampane, Rose first extracted the peculiar vegetable principle called *inulin.* M. Funke has since given the following as the analysis of elecampane root:—

A crystallizable volatile oil,
Inulin,
Extractive,
Acetic acid,
A crystallizable resin,
Gluten,
A fibrous matter (ligneous).

ELECTRICITY. The phenomena displayed by rubbing a piece of amber, constitute the first physical fact recorded in the history of science. Thales of Miletus, founder of the Ionic school, ascribed its mysterious power of attracting and repelling light bodies, to an inherent soul or essence which, awakened by friction, went forth and brought back the small particles floating around. In times near to our own, the same hypothesis was resorted to by the honourable Robert Boyle. From *electron*, the Greek name of amber, has arisen the science of electricity, which investigates the attractions and repulsions, the emission of light, and explosions, which are produced, not only by the friction of vitreous, resinous, and metallic surfaces, but by the heating, cooling, evaporation, and mutual contact of a vast number of bodies.

1. *General statement of electrical phenomena.*

If we rub, with a dry hand or a silk handkerchief, a glass tube, and then approach it to bits of paper or cotton, to feathers, or, which is better, gold leaf, it will first attract these bodies, and then repel them. If the tube be held parallel to a table on which they have been laid, an electrical dance will be performed. If to the farther end of the tube we hang a brass ball, by a thread of linen, hemp, or a metallic wire, the ball will participate with the rubbed tube in its mysterious powers. But if the ball be suspended by a cord of silk, worsted, or hair, or by a rod of glass, wax, or pitch, the attractive and repulsive virtue will not pass into it.

When the atmosphere is dry, if we take in one hand a rod of glass, and in the other a stick of sealing-wax, and after having rubbed them against silk or worsted, approach one of them to a bit of gold leaf floating in the air, it will first attract and then repel it. While the film of gold is seen to avoid the contact of the rod which it has touched, if we bring the other rod into its neighbourhood, attraction will immediately ensue; and this alternate attraction and repulsion may be strikingly displayed by placing the two excited rods at a small distance asunder, with the gold leaf between.

If we suspend close together, by silk threads, two cylinders of rush-pith, and touch their lower ends with either the rubbed wax or glass, the pieces of pith will instantly recede from each other at a considerable angle. If we now merely approach to the bottom of the diverging cylinders the rod with which they had been touched, their divergence will increase; but if we approach the other rod, they will instantly collapse through their whole extent. When the rods are rubbed in the dark, a lambent light seems diffused over them, and a pungent spark will pass into a knuckle brought near them. If the person who makes these experiments happens to stand on a cake of wax, or a stool with glass feet, then, on rubbing the glass tube, he will acquire the above attractive and repulsive powers; but the light bodies repelled by the tube will be attracted by his body, and *vice versa.*

Hence we see that the *rubbing* body acquires electrical properties dissimilar to those acquired by the substances *rubbed*.

Such is a sketch of the elementary phenomena of electricity. The science, in its modern augmentation, seems to comprehend almost every change of the corpuscular world, however minute and mysterious, as well as the long recognized and magnificent meteors of the atmosphere. Let us now take a methodical view of them, as far as the limits of our work will permit. We shall consider electrical phenomena under four heads:—

1st, Of the EXCITEMENT of Electricity, or the various means by which the electrical equilibrium is disturbed.

2d, Of the *Two Electricities*.

3d, Of the DISTRIBUTION of Electricity.

4th, Of the Voltaic Battery and its EFFECTS: calorific, or igniting; and decomposing, or the chemical agencies of electricity.

Concerning the nature of the electrical essence, we are equally in the dark as concerning the nature of caloric. The phenomena may be referred, in both cases, either to a peculiar fluid, whose particles are endowed with innate idio-repulsive powers, or to a peculiar affection of the molecules of common matter.

I. *Of Electrical Excitement.*

1. The mutual *friction* of all solids, whether similar or dissimilar, and of many fluids against solids, will invariably excite electrical phenomena, provided one of the bodies be of such a nature as to obstruct the speedy diffusion of the electrical virtue. Hence we must commence with a list of electrical conductors and non-conductors.

1st, The following substances conduct or favour the rapid distribution of electricity. Those at the head of the list possess a conducting power greater than that of water, in the proportion of three millions to one.

1. Copper
2. Silver
3 Gold
4. Iron
5. Tin
6. Lead
7. Zinc
8. Platinum
9. Charcoal
10. Plumbago
11. Strong acids
12. Soot and lamp-black
13. Metallic ores
14. Metallic oxides
15. Dilute acids
16. Saline solutions
17. Animal fluids
18. Sea water
19. Water
20. Ice and snow above 0°
21. Living vegetables
22. Living animals
23. Flame
24. Smoke
25. Vapour
26. Salts
27. Rarefied air
28. Dry earths
29. Massive minerals.

Voltaic electricity affords the means of measuring the relative conducting powers of bodies with far greater precision than common electricity. In this way Sir H. Davy discovered that the conducting power of metallic bodies varied with the temperature, and was *lower* in some inverse ratio as the temperature was higher. Thus, a wire of platinum of $\frac{1}{220}$ of an inch, and 3 inches in length, when kept cool by oil, discharged the electricity of two batteries, or of 20 double plates; but when suffered to become heated in the air, it barely discharged one battery. Six inches of silver wire of $\frac{1}{220}$ discharged the whole of the electricity of 65 pairs of plates of zinc, and double copper, made active by a mixture of about one part of nitric acid of commerce, and fifteen parts of water. Six inches of copper wire of the same diameter, discharged the electricity of 56 pairs of the same combination; 6 inches of tin, 12 pairs of plates only; 6 of platinum, 11; and 6 of iron, only 9. All the wires were kept as cool as possible by immersion in a basin of water. Lead and copper were much alike. *Phil. Trans.* 1821.

M. Becquerel, by the aid of an electro-magnetic apparatus, obtained the following results on the conductibility of metals, when kept cool:—

Copper . .	100·00
Gold . .	93·60
Silver . .	73·60
Zinc . .	28·50
Tin . .	15·50
Platinum . .	16·40
Iron . .	15·80
Lead . .	8·30
Mercury . .	3·45
Potassium . .	1·33

Annales de Chim. et Phys. xxxii. 420.

2d, The following is a list of electrical non-conductors, in the order of their insulating power.

1. Shel llac
2. Amber
3. Resins
4. Sulphur
5. Wax
6. Asphaltum
7. Glass, and all vitrified bodies, comprehending diamond and crystallized transparent minerals
8. Raw silk
9. Bleached silk
10. Dyed silk
11. Wool, hair, and feathers
12. Dry gases
13. Dry paper, parchment, and leather
14. Baked wood, and dried vegetables
15. Porcelain
16. Marble
17. Massive minerals, non-metallic
18. Camphor
19. Caoutchouc
20. Lycopodium
21. Dry chalk and lime
22. Phosphorus
23. Ice below 0° of Fahr.
24. Oils, of which the densest are best
25. Dry metallic oxides, including fused alkalies and earthy hydrates.

The general arrangement of the above list is tolerably correct, though it is probable that phosphorus, when freed from adhering moisture, would stand higher among insulators.

All material substances have been usually divided into two classes; of electrics, and non-electrics. But this distinction is groundless, and calculated to mislead. Every substance is an electric, or capable by friction of exhibiting electrical phenomena. Thus, if we take any of the bodies in the first list, which are commonly called non electrics, for instance a copper ball, and insulating it by a rod of any convenient solid in the second list, if we rub the ball with a piece of silk or worsted, we shall find it to become electrical. It will attract and repel light bodies, and will give lucid sparks to a finger which approaches it. To account for these appearances, it has been said that the electrical equilibrium, which constitutes the common state of matter, is disturbed by the friction; and that one of the two bodies attracts to itself a surcharge of the electrical fluid, while the other remains in a deficient state; whence the terms of positive and negative, or plus and minus, have arisen. Many of the appearances, however, are reconciled with difficulty to a mere excess or deficiency of one fluid; and hence the hypothesis of a compound fluid, susceptible of decomposition by friction and other means, has been introduced. The resulting fluids are necessarily coexistent, the one appearing on the body rubbed, and the other on the rubber; but since the one is most usually evolved on the surface of glass, and the other on that of resins, the first has been called the vitreous, and the second the resinous electricity. These two fluids, corresponding to the positive and negative of Franklin, by their reunion produce a species of reciprocal neutralization, and electrical repose. Some recent investigations of that profound physico-geometer M. Poisson, render the second explanation the less improbable of the two. Let us always bear in mind, however, that the hypothetical thread which we employ at present to tie together the scattered facts of electricity, is probably very different from the chain of nature.

There seems to be no physical quality common to the conductors, or to the non-conductors. The crystalline arrangement always introduces non-conducting qualities, more or less perfect, if we exclude the metals. Thus carbon, in the pulverulent or fibrous form, is an excellent conductor; but crystallized in diamond, it becomes an insulator. The same difference exists between water and ice, and also between pounded and compact glass. That pounded glass is indeed a conductor, appears from my experiments to be certainly the case. Glass, resins, and fats, which in the solid state are non-conductors, become conductors on being melted.

On the evolution of electricity by friction, is founded the construction of our common electrical machines. It was supposed at one time, that their action was connected with the oxidizement of the amalgam, which is usually applied to the face of the rubber. But Sir H. Davy having mounted a small machine in a glass vessel, in such a manner that it could be made to revolve in any species of gas, found that it was active in hydrogen, and more active in carbonic acid than even in the atmosphere. Indeed, if we recollect that the friction of surfaces of glass, silk, or sealing-wax, is sufficient to produce electrical appearances, we cannot suppose oxidizement of metal to be essential to their production. If we even impel a current of air, or a minute stream of pure mercury, on a plate of dry glass, electrical excitement will result.

The electrical phenomena excited by friction are generally so energetic, as to require nothing but bits of any light matter for their exhibition. When we have to detect the disturbance of the electrical equilibrium, occasioned by other and feebler causes, more refined *electroscopic* means are required. The most delicate of simple electroscopes consist of two oblong narrow slips of gold leaf, suspended from the centre of the brass cap of a glass cylinder, about 2 inches diameter, and 6 inches long. The bottom of the cylinder should rest in a metallic sole; from which, on the opposite sides, two narrow slips of tin-foil should rise up the inner surface of the glass to the level of the middle of the pendent slips of gold leaf. Coulomb's electroscope, which acts by the torsion of a fibre of the silk-worm, suspending in a glass case a horizontal needle of shell lac, terminated in a little disc of gilt paper, is still more sensible, and is much employed by the Parisian philosophers. Aided by either of these instruments, we can observe the excitement of electrical phenomena in the following cases, independent of friction.

2. In the *fusion* of inflammable bodies. If we pour melted sulphur into an insulated metallic cup, we shall find after it concretes, that the sulphur and cup will be both electrified; the former with the vitreous, the latter with the resinous electricity; or sometimes reversely. But Messrs. Van Marum and Troostwyck, from a series of experiments which they made on a number of bodies, were led to conclude that the electricity was produced in such cases as the above, either by the friction from change of bulk when the melted matter concretes, or from the friction which the electrical bodies undergo when they spread upon the surfaces of other bodies, upon which they are poured in the liquid state. When glacial phosphoric acid congeals, and when calomel concretes in sublimation, electrical phenomena are produced. The experiments of Henly on the electricity excited during the concretion of melted chocolate, do not seem easily explicable on the principle of friction. When it is cooled in the tin pans into which it is first re-

ceived, the electricity is strong, and continues for some time after it is removed. When it is again melted and allowed to cool, the electrical virtue is restored, but not to its former strength. After the third or fourth fusion, the electricity becomes extremely weak. When the chocolate is mixed with a little olive oil before it is poured out of the pan, it then becomes strongly electrical. Now, in so far as friction is concerned, we should have the electrical phenomena as decided at the fourth fusion, as the first; and the presence of oil ought to lessen the effect, as it diminishes the friction. It is highly probable that the act of crystallization always induces a change of the electrical equilibrium; as the crystalline structure changes the electrical relations in general.

3. Electricity produced by *evaporation*.

If on the cap of the gold leaf electroscope we place a small metallic cup, containing a little water, and drop into it a red-hot cinder, the gold leaves will instantly diverge to a very considerable angle. Or if we insulate a hot crucible of iron, copper, silver, or porcelain, and pour into it a few drops of water, alcohol, or ether, on connecting the crucible with an electroscope, electrical phenomena will appear.

4. Electricity produced by *disengagement* of gas.

If into a platinum cup, resting on the top of the electroscope, we put a little dilute sulphuric acid, and then throw in some iron filings or chalk, the gold leaves will diverge as the effervescence becomes active. The same thing is producible with nitric acid and copper filings.

5. Electricity produced by disruption of a solid body.

If we suddenly tear asunder plates of mica, break across a stick of sealing-wax, cleave up a piece of dry and warm wood, or scrape its surface with window glass, or finally cause a bit of unannealed glass, such as a Prince Rupert's drop, to fly asunder by snapping off a bit of its tail, the electrical equilibrium will be disturbed. Most of these cases may, however, be probably referred to friction among the moleculæ. To the same head we may also refer the electricity excited by sifting various powders and metallic filings through a metallic sieve, or by dropping them on insulated plates.

6. Electricity excited by *change* of temperature.

M. Haüy made the important discovery, that the property of exhibiting electrical phenomena by heat, belongs to those crystals only whose forms are not symmetrical; that is to say, of which one extremity or side does not correspond with the opposite. Thus, for example, the variety of tourmaline which he calls *isogone*, a prismatic crystal of nine sides, terminated at one end with a three-sided, and at the other with a six-sided pyramid, when exposed to the temperature of 100° Fahr. shows no sign of electricity. But if we plunge it for some minutes into boiling water, and taking it out with small forceps, by the middle of the prism, present it to the cap of the electroscope, or to a pith ball pendulum already charged with a known electricity, we shall find it will attract it with one of its poles, and repel with the other. The three-sided pyramid possesses the resinous, and the six-sided the vitreous electricity. Although an elevation of temperature be necessary to develop this property, it is not needed for its maintenance. It will continue electrical for six hours after its temperature has fallen to the former point, especially if it be laid on an insulating support. In fact, it loses its electricity more slowly than a piece of glass in similar circumstances.

This property of attracting light bodies when heated, was recognized by the ancients in tourmaline, which was probably their *lyncurium*. The Dutch in Ceylon gave it the name of *Aschentrikker*, from its attracting the ashes when a piece of it was laid near the fire. It appears that a heat above 212° impairs its electrical activity; and that it is some time before it recovers its pristine virtue. When the tourmaline is large, it is capable of emitting flashes of electrical light. The Brazilian or Siberian topaz exhibits the same phenomena by being slightly heated. The topazes of Saxony, and the blue topaz of Aberdeenshire, are electrical only by friction. Boracite, mesotype, and crystallised calamine, possess similar properties of becoming electrical with heat.

7. Electricity produced by contact of dissimilar bodies. If we take two flat discs, one of silver or copper, and another of zinc, each two or three inches diameter, furnished with glass handles, and bring them into momentary contact by their flat surfaces, we shall find, on separating them, that they are both electrified. If we touch a disc of sulphur gently heated with the insulated copper plate, the electrical effects will be still more striking. Acid crystals, touched with metallic plates, yield electrical phenomena. Finally, crystals of oxalic acid, brought into contact with dry quicklime, develope electricity. On the excitation of electricity by contact of dissimilar chemical bodies, is founded the principle of galvanic action, and the construction of the voltaic battery. Of this apparatus we shall treat in the sequel.

If dry oxalate of lime be stirred in a capsule of metal, &c. with a platinum spatula, it becomes so strongly electrical, that it cannot be collected together, but flies about the dish whenever it is moved, and even over its sides. It requires some little stirring before the particles of the powder are all of them sufficiently electrical to produce this effect. After it is excited, if it be shaken in small quantity, on the cap of a gold leaf electrometer, the leaves diverge 2 or 3 inches. The powder requires to be recently and thorough dried to show these effects, as it is of a very hygrometric quality. Platinum rubbed against the powder becomes negative; the powder, positive; and all other metals tried, the same as platinum. When rubbed with glass, the glass became strongly negative, the oxalate positive, both being dry and warm. This body, therefore, appears to stand at the head of the list of all substances as yet tried, as to its power of becoming positively electrical by friction. Oxalates of zinc and lead produce none of these effects. *Mr. Faraday, Journal of Science,* xix. 338.

II. *Of the two Electricities.*

We have already stated, that the two electricities are always connate and simultaneous. If they result from the decomposition of a quiescent neutral compound fluid, we can easily see that this co-existence is inevitable. Hence also we can understand, how any body by friction may be made to exhibit either of the two electricities, according to the nature of the rubber. The only exception is the back of a living cat, which gives vitreous electricity with every rubber hitherto tried. To know the species of electricity evolved, it is merely necessary to communicate beforehand, to the slips of gold leaf, a known electricity, either from excited glass or sealing wax. If they be divergent with the former, then the approach of a body similarly electrified will augment the divergence, but that of one oppositely electrified will cause their collapse.

The following is a table of several substances which acquire the vitreous electricity, when we rub them with those which follow them in the list; and the resinous electricity, when rubbed with those that precede them.

The skin of a cat.
Polished or smooth glass.
Woollen stuff or worsted.
Feathers.
Dry wood.
Paper.
Silk.
Lac.
Roughened glass.

No visible relation can be pointed out between the nature or constitution of the substances, and the species of electricity which is developed by their mutual friction. The only general law among the phenomena is, that the rubbing, and the rubbed body, always acquire opposite electricities. Sulphur is vitreously electrified when rubbed with every metal except lead, and resinously with lead and every other kind of rubber. Resinous bodies rubbed against each other, acquire alternately the vitreous and resinous electricity; but, rubbed against all other bodies, they become resinously electrical. White silk acquires vitreous electricity with black silk, metals, and black cloth; and resinous with paper, the human hand, hair, and weasel's skin. Black silk becomes vitreously electrical with sealing-wax; but resinously with hares', weasels' and ferrets' skins; with brass, silver, iron, human hand, and white silk. Woollen cloth is strongly vitreous with zinc and bismuth; moderately so with silver, copper, lead, and specular iron. It is resinous with platina, gold, tin, antimony, gray copper, sulphuret of copper, bisulphuret of copper, sulphurets of silver, antimony, and iron. When two ribands of equal surface are excited by drawing one lengthwise over a part of the other, that which has suffered friction in its whole length becomes vitreously, and the other resinously electrical. Dry air impelled on glass becomes resinously electrical, and leaves the glass in the opposite state. Silk stuffs agitated in the atmosphere with a rapid motion, always take the resinous electricity, while the air becomes vitreously electrified. A riband of white silk, rubbed against a well dyed black one, affords always marks of vitreous electricity; but if the black silk be much worn, and the white riband be heated, it will yield signs of resinous electricity, and, on cooling, it will again exhibit marks of the vitreous. The general result which was deduced by M. Coulomb, from his very numerous and exact experiments on this curious subject, is the following:—

When the surfaces of two bodies are rubbed together, that whose component parts recede least from each other, or elevate least from their natural position of repose, appear, in consequence, more disposed to assume the vitreous electricity; this tendency augments if the surface experiences a transient compression. Reciprocally, that surface whose particles deviate most from their ordinary position by the violence of the other, or by any cause whatever, is, for that reason, more disposed to take the resinous condition. This tendency increases if the surface undergo a real dilatation. The stronger is this opposition of circumstances the more energetic is the development of electricity on the two surfaces. It grows feebler in proportion as their state becomes more similar. Perfect equality would nullify the phenomena, provided it could exist. Thus, when a dry animal or vegetable substance is rubbed against a rough metallic surface, it exhibits signs of resinous electricity. In this case, its parts are forcibly separated. When, on the other hand, it is rubbed on a polished metal, which scarcely affects its surface, or merely compresses the particles, it either affords no evidence of electricity, or it exhibits the vitreous kind. Heat, by dilating the pores, acts on the surfaces of bodies as a coarser rubber would do. It disposes them to take the resinous electricity. Thus also new black silk, strongly dyed, being rubbed against a riband of white silk, takes always the resin-city than the black silk, and consequently makes it vitreous. This disposition vanishes, as might be expected, with the accidental cause that produced it, and the white riband, on becoming cold, reacquires the vitreous electricity. The black dye produces on wool the same effect as on silk. A white riband, rubbed against white woollen stuff, gives always signs of resinous electricity; but, against wool dyed black, it affords signs of the vitreous electricity. I have entered somewhat minutely into the detail of the apparently trifling causes which give birth to the one or the other electricity, as they may tend to throw some light on the electricities evolved among chemical bodies by friction or simple contact. It has been supposed, indeed, that uncombined acids, alkalis, and metals, are naturally and constantly in an electrized condition; the first resinously, the second and third vitreously. But of this position, there is neither probability nor evidence. The electricity produced by their contact, on an extensive surface, with other bodies, is evidently a disturbance of the pre-existing equilibrium. A wire connected with the most delicate electroscope of torsion, which moves through 90° with a force of less than 1-100,000th of a grain, will indicate no electricity, when made to touch the most energetic acid or alkaline body.

In describing the two electricities, we must not omit the interesting observations of Ehrman. There are substances of the imperfect conductor class, which are capable of receiving only one kind of electricity, when made to form links in the voltaic chain. M. Ehrman styled them *unipolar* bodies. Perfectly dry soap, and the flame of phosphorus, when connected with the *two* extremities of the voltaic apparatus, and with the ground, discharge connected with only *one* pole of the pile, and with the ground, destroy the divergence of the leaves of the electroscope attached to that pole. To render these results manifest, insulate in dry weather a battery of about 200 pairs of plates. Connect with each extreme pole the cap of a gold leaf electroscope, by a moveable wire. When either electroscope is brought in contact with soap communicating with the ground, the slight divergence of the gold slips ceases. But when the soap is connected with both electroscopes, and also with the ground, the divergence of the leaves of the electroscope, attached to the zinc end or vitreously electrified pole, will continue, while the leaves of the other electroscope will collapse. The inverse order of effects occurs, or the zinc electroscope collapses, when the flame of a taper is connected with both electroscopes and with the ground.

Mr. Brande, in an ingenious paper published in the Phil. Trans. for 1814, has endeavoured to explain the curious phenomena with regard to flames in another way. As some chemical bodies are supposed by him to be naturally in the resinous, and others in the positive electrical state, he supposes that the positive flame will be attracted and neutralize the negative polarity, while the negative flame will operate a similar restoration of the equilibrium at the positive pole. To determine the truth of this hypothesis, he placed the flames of various bodies between two insulated brass spheres, containing each a delicate thermometer. His first experiment verified Mr. Cuthbertson's observation, that the flame of a candle communicates its heat chiefly to the negative ball, both being feebly electrified by a cylindrical machine of Nairne's construction.

Flames attracted by the

Positive Ball.

Phosphuretted hydrogen, slightly.
Carbonic oxide in a small stream, doubtful.
Ditto in large stream.
The acid from the flame of sulphur.
Flame and acid fumes of phosphorus.
Stream of muriatic acid gas, shown by coating the balls with litmus paper.
Stream of nitrous acid.
Vapour of benzoic acid.
Ditto of amber.

Negative Ball.

Olefiant gas.
Sulphuretted hydrogen, slightly; its sulphurous acid vapour passed off to the positive ball.
Arsenuretted hydrogen; its arsenious acid passed feebly to the other ball.
Hydrogen; result doubtful, from equality of attraction.
Flame of carburet of sulphur; its acid fumes passed to the positive.
Flame and alkaline fumes of potassium.
Flame of benzoic acid.
Flame of camphor.
Flame of resins.
Flame of amber.

is obvious, that when connected with the *positive* pole of the battery, and with a gold leaf electrometer, the leaves will continue to diverge; but when applied to the negative pole, that electrical state will be annihilated by the inherent positive energy of the flame, and consequently the leaves of the negative electrometer will not diverge. On the other hand, the flame of phosphorus is negatively unipolar. Now it has been shown that this flame, (owing probably to the rapidity with which it is forming a powerful acid, by combination with a large quantity of oxygen), is attracted by the positively electrified surface, and consequently that it is itself negative, so that it would transmit negative electricity to the electrometer, but would annihilate the negative power, and thus appear as an insulator under the particular circumstances which M. Ehrman has described." I shall not stop to investigate the justness of these ingenious conclusions. They do not affect the unipolarity of dry soap: which on Mr. Brande's theory of that of flames, should be naturally and permanently in the state of positive electricity; which we know it not to be.

III. *Of the Distribution of Electricity.*

Under this head we shall be able to arrange several important phenomena, which, by their disjunction have been frequently rendered complex and difficult of comprehension. We shall treat, in the first place, of the distribution of *either* electricity, insulated in one body, and in a system of bodies in contact: in the second place, the distribution of electricity in a system of contiguous bodies, not in contact.

1. If we communicate electricity to an insulated metallic sphere, we shall find the whole electric power diffused over its surface, and the particles in its interior absolutely devoid of the least electric virtue. Let the ball of iron or brass have a hole of about an inch diameter, reaching to its centre. Then on touching the centre with a metallic spherule attached to the end of a needle of lac, and instantly applying it to a delicate electroscope, we shall perceive no sign of electricity whatever. If the spherule, however, touch the outer edge of the hole, or the surface of the globe at any point, it will acquire a very manifest electricity. Hence, if we apply for a moment to the surface of an electrified 24 pound shot, two hemispherical cups of tinfoil, furnished with insulating handles, we shall find that the whole electrical virtue has passed into the cups, whose weight may not equal the ten-thousandth part of that of the ball. This distribution is totally independent of the nature of the substance, and is deducible from the law discovered by Coulomb, that electrical attractions and repulsions are inversely as the squares of the distances, that whatever be the figure of the body, the distribution of the electric fluid on its surface will be the same with the thin stratum in its interior. If the proposed spheroid be an ellipsoid, the inner surface of the electrical stratum will be also a concentric and similar ellipsoid, for it is demonstrated that an elliptical stratum, whose surfaces are thus concentric and similar, exercises no action on a point placed in its interior. The thickness of the layer in each of its points is found generally determined by this construction. It hence results that this thickness is greatest at the summit of the greater axis, and least at the summit of the smaller. The thickness corresponding to the different summits, are to each other as the lengths of their respective axes.

2. Were the atmosphere and the glass support perfect non-conductors, the above distribution would continue till some other body was brought near to, or in contact with, the ball. But the surface of even lacquered glass yields slowly to the idio-repulsive power of the electrical fluid; and the atmosphere, partly by its aqueous particles, and partly by its own feebly conducting power, continually robs the globe of its electricity. The immediate aërial envelope no sooner acquires electric impregnation than it recedes, and is replaced by a new sphere of gaseous particles. By this intestine aërial movement of repulsion and attraction, the ball, in a short time, loses its excess of vitreous or resinous electricity, and resumes the neutral state. By placing it in the centre of a dry glass receiver, the period of electrization may be prolonged, but, sooner or later, the electric equilibrium is restored between it and the surrounding matter.

3. If we bring into contact with the above electrized ball, an unelectrified one of the same bulk, but of a very different weight, we shall find an equal distribution to take place between them. An insulated disc or spherule, applied to the surface of each, will be capable of affecting a graduated electrometer of torsion, to the same degree. We thus perceive that bodies do not act on electricity by any species of elective attraction or affinity. They must be regarded merely as vessels, in which this power is distributed agreeably to the laws of mechanics.

When the above globes are separated, their electricities diffuse themselves uniformly about them, and the quantities are found equal when the surfaces are so. But if the surfaces be unequal in any given ratio, it then happens that the quantity of electricity varies in a different ratio, which is less than that of the surfaces. Thus Coulomb ascertained, that when the surface of the smaller globe was nearly one-fifteenth of that of the larger, its quantity of electric fluid was one-eleventh. The following is his general table of results.

Surface of sphere,	Density in little sphere, whose surface = 1.
1	1
4	1·08
16	1·30
64	1·65
Infinite,	less than 2·00
Do. calculated by M. Poisson,	1.65

The difference therefore can never amount to two. He placed two globes, each of two inches diameter, in a line with a globe of eight inches diameter; the two smaller ones being in contact, and one of them with the larger. He found that the quantity of electricity of the smaller globe, most distant from the greater, was to that of the intermediate as 2·54 to 1. Four globes of two inches being placed in a row, successively in contact with each other, and with a globe of eight inches diameter, the ratio of the quantities of electricity taken by the small globe, farthest from the large one, and that nearest it, was found to be 3·4 to 1. Having placed 24 globes, each of two inches diameter, in a like series with the larger globe, Coulomb compared the 24th little globe, that is to say, the last in the row, with others in the same row, and the results were as follow:—

24th to the 23rd as 1·49 to 1
24th to the 12th as 1·7 to 1
24th to the 10th as 2·1 to 1
24th to the 1st which was in contact with the large globe, as 3·72 to 1
24th to that of the large globe, as 2·16 to 1

When two electrified spheres, of equal size, in contact, are examined as to the state of the electricity on the different points of their surfaces, we have the following relations:—

Position of the points compared.		Ratio of the second thickness to the first.
90° and	20°	insensible
90	30	0·2083
90	60	0·7994
90	90	1·0000
90	180	1.0576

If the diameters of the two globes be as 2 to 1:

90° and	30°	insensible
90	60	0·5882
90	90	1·0000
90	180	1·3333

That, in ordinary cases, electricity is confined to the surfaces of bodies, not merely by the non-conducting faculty of the air, but by a species of mechanical pressure which air exercises, becomes evident, when we lessen the density of the air by exhaustion. Though the conducting aërial particles are thus greatly diminished in number, rendering the insulation apparently more complete, yet the electric power now emanates with vast rapidity from the electrised ball, in visible coruscations. Rarefied air is therefore a good conductor.

4. By touching various points of insulated electrized bodies with a little disc of metallic foil, cemented to the end of a needle of lac, which he applied to his electrometer, M. Coulomb ascertained the variation of electrical density that exists at different points on the surfaces of bodies, of different forms and magnitudes. He thus found, that towards the extremities of all oblong conducting bodies, whether thin plates, prisms, or cylinders, there is a rapid augmentation of the electricity. He insulated a circular cylinder of two inches diameter and thirty inches in length, terminated at each end with a hemisphere. By comparing the quantities of electricity accumulated at the centre, and at various points, near to its extremities, he found—

	The ratio of the second electrometric torsion to the first.
Touched at the middle and 2 inches from the end, to be	1·25
At 1 from ditto, . . .	1·80
And at the end, . . .	2·30

When the cylinder becomes more and more slender towards its extremities, the increase of electricity becomes in these parts more considerable, and more rapid. Lastly, if the extremity of the cylinder be prolonged like the apex of a cone, the accumulation which occurs at this point becomes so strong, that the resistance of the air is no longer sufficient to retain the electricity on the surface of the conducting body, and it escapes in luminous coruscations, visible in the dark. In this case, the uniform distribution of electricity extends to a very small distance from the pointed extremity. We thus perceive why bodies furnished with sharp projections rapidly lose the electricity communicated to them. In like manner, a circular plate of five inches diameter, when electrified, has at its centre an intensity of 1, at one inch from it 1.001, at two inches 1.005, at three inches 1.17, at four inches 1.52, at four and a half inches 2.07, and at the border 2.9 times that of the centre. We can thus understand how electrical machines, furnished with elongated prime conductors, furnish very vivid sparks.

Of the distribution of electricity among contiguous bodies, not in contact.

Let us examine first what happens when two electrified spheres separated from contact, are removed to a little distance from each other. A very remarkable phenomenon is then developed. We have seen, that during contact, the electricity is of the same nature on the two spheres. To fix our ideas, let us suppose it to be vitreous. We have likewise seen that it is null at the point of contact. Now, at the instant of separating the two spheres, if their dimensions be unequal, this neutrality no longer exists. A part of the combined electricity of the small sphere is decomposed, and that which is of a nature opposite to the electricity of the great sphere, namely the resinous in the present example, is carried towards the point where the contact occurred. This effect diminishes according as we remove the two spheres from one another, and it becomes null at a certain distance, which depends on the ratio of their *radii*. Then the point of the little sphere, where the contact was, passes back into its state during the contact, that is to say, it has no species of electricity. Departing from this term, if we augment the distance, the electricity remains of the same nature over the whole surface of the little sphere, and that nature is the same as during the contact. These phenomena are always peculiar to the smaller of the two spheres, whatever may be the quantity of electricity communicated to them. On the larger sphere, the electricity is always and throughout of the same kind as at the moment of contact.

In an experiment made by Coulomb, the great globe being eleven inches, and the small four in diameter, the opposition of the two electricities continued till the distance became two inches. When the diameter of the latter was only two and a half inches, the opposition continued till the distance became two and a half inches, but not beyond. When the globes are equal, these peculiarities do not take place.

When two oppositely electrised spheres are gradually approached towards each other, the thickness of the electric coating at the nearest points of their two surfaces becomes greater, and increases indefinitely as their distance diminishes. The pressure exercised by the electricity against the plate of air interposed between the two bodies, augments progressively, and terminates by overcoming the resistance of the air. The fluid then escaping under the form of a spark or otherwise, must pass previous to the actual contact from one surface to the other.

This action at a distance is a key to the principal phenomena of electricity.

In our first inquiries we remarked, that electrized bodies attract, or seem to attract, all the light matters presented to them, without its being necessary to develop in the latter the electric faculty, either by friction or communication. But now we must conceive, that this development is spontaneously effected by the mere influence, at a distance, of the electrized body, on the combined electricities of the small bodies around. Thus all the attractions, whether real or apparent, which we observe, take place only between electrized bodies.

When, therefore, an insulated conducting body B, which is in the natural state, is put in presence of another insulated electrized body A, the electricity distributed on the surface of A, acts by influence on the two combined and quiescent electricities of B, decomposes a quantity of them proportional to the intensity of its action, resolving it into its two constituent principles. Of these two electricities become free, A attracts the one, and repels the other. The second is carried to the portion of the surface of B, which is most remote from A; the first to the contiguous surface. These two electricities react in their turn on the free electricity of A, and even on its combined electricities, of which one part is decomposed by this reaction, and is separated, if the body A be also a conductor. This new separation induces a new decomposition of the combined electricity of B; and thus in succession, till the quantities of each principle become free, or the two bodies come into an equilibrium, by the balancing of all the attractive and repulsive forces which they mutually exercise, in virtue of their similar or dissimilar nature.

If A is vitreously electrised, and the conductor B is a cylinder, the end of it adjoining to A will be resinous, and the remote end vitreous, while the middle portion will be nearly neutral.

If we now touch this remote end with a third insulated conductor C, in the natural state, and then remove it, we shall find it charged with vitreous electricity. Or if we touch the remote end of the second conductor with a finger, and after withdrawing it separate the first and second insulated conductors to a considerable distance, we shall find that B has acquired electricity, independent of the presence of A. Had we not touched it, however, then on putting them asunder, B, no longer exposed to the influence of A, would instantly recover its natural state. The two decomposed electricities would in this case flow back from the extremities, and recombining, restore the equilibrium. If A was vitreous, the touch of an unelectrified finger would make B pass into the resinously electrical state, by opening a channel, so to speak, for the repelled vitreous electricity to escape. We see also how this action and reaction may prodigiously increase the intensity of an electricity originally very feeble. On this principle we can at pleasure communicate to an insulated conductor, either of the electricities, from one electrified body or source.

Thus, having excited a stick of sealing-wax by rubbing it on the sleeve of our coat, we may make this resinous electricity produce either the resinous or the vitreous state, in the gold leaves of an electroscope. If we hold the stick at a little distance, above the cap of the electroscope, the leaves will immediately diverge; and if we then remove it, they will instantly collapse. If we now touch the cap for an instant with the sealing-wax, the leaves will acquire the same electrical state; they will continue divergent, with resinous electricity. Let us restore the natural state, by touching the cap with our finger. Holding again the sealing-wax a little above the electroscope, let us then touch its cap for a moment with our finger, and after removing it, withdraw the wax—we shall perceive the leaves continue to diverge, and on trying the species of electricity, we shall find it to be the vitreous; for the approach of excited wax will make the divergence diminish, while that of excited glass will make it increase.

These reciprocal attractions, repulsions, and decompositions of the electrical compound, explain perfectly the action of the condenser of electricity as contrived by Œpinus or Volta, and improved by Cuthbertson; of the electrophorus; of the Leyden jar; and in some measure, of that mysterious apparatus, the voltaic battery. To this subject, all our preceding electrical researches may be considered as merely introductory; for this instrument constitutes the great link between electricity and chemistry, deriving probably its uninterrupted series of impulsive discharges, and consequently its marvellous power of chemical analysis, from the conjoined agencies of electricity and elective attraction.

IV. *Of Voltaic Electricity.*

The accidental suspension of recently killed frogs, by copper hooks, to the iron palisades of his garden, was the occasion of the celebrated Galvani observing certain convulsive movements in the limbs of the animals, which no known principle could explain, and thenceforth of opening up to mankind a rich and boundless field in physical science. As the practical nature of this work precludes us from entering into historical details, we shall at once proceed to describe the present state of *voltaic electricity*, and *electro-chemistry*. Galvani had ascribed the muscular movements to a series of discharges of a peculiar electricity, inherent and innate in living beings, to which the name *animal electricity*, or the more mysterious term *galvanism*, was for some time given. Volta proved, that the phenomena proceeded from the contact of the two dissimilar metals, copper and iron, producing such a disturbance of the electrical equilibrium, as was sufficient to affect the most delicate of all electroscopes, the irritability of a newly killed frog, though it was insensible to every electroscope of human construction. He fully verified this fine theory by showing, that a few contacts of the dissimilar metals, zinc and silver, in the form of discs, furnished with insulating handles, were capable of affecting the common condenser of electricity. Galvani, however, anxious to defend his own hypothesis, which linked his name to the science, adduced some curious facts, which proved that muscular convulsions could be produced in the limbs of dead frogs, altogether independent of metals. This led Volta to the further discovery, that other dissimilar bodies besides metals were capable, by contact, of disturbing the electrical equilibrium.

Since a slender rod of silver and of zinc, touching each other at one of their ends, and at the other brought into contact with the nerve and muscle, or spine and toes of a dead frog, could excite powerful convulsions, it occurred to Volta, that a repetition, on a more extended surface of that simple series of two metals and moisture, might produce a combined effect, capable of being felt by the human hand. By a most philosophical prosecution of his own principle, he happily succeeded in constructing, by regular alternation of discs of silver, zinc, and moistened cloth or pasteboard, reared in a columnar form, the electro-chemical pile and battery, which will associate the name of Volta to that of Galvani through each succeeding age. The compound metallic arcs of copper and zinc, with which he connected a circle of cups containing salt water, to form his *couronne des tasses*, may be regarded as the same apparatus in a horizontal, instead of a columnar arrangement. The former construction was happily modified by Mr. Cruikshanks into the voltaic trough; while the latter has suggested the arrangement of parallel porcelain cells, into which a concatenated series of compound metallic plates is immersed.

Amid the crowd of philosophers, who, after Galvani and Volta, entered this arduous field, two are pre-eminent for the ingenuity and success of their investigations, Dr. Wollaston and Sir H. Davy. The first had the singular merit of tracing up the analogy between the mysterious operations of galvanic and of common electricity; and afterwards invented an apparatus, by which this agent can excite vivid ignition in almost a microscopic compass. Of the discoveries made by Sir H. Davy in voltaic electricity and in chemistry, by the sagacious application of its unlimited powers, it is difficult to speak in the cold language of philosophy. They probably surpass in importance, as they do in splendour, the united discoveries of preceding chemists; and when the breath of contemporary envy shall sink into the grave, they will shine forth on the diadem of English science, companion gems to the diamond of Newton.

I shall now endeavour to give a brief survey of voltaic phenomena, conducting my steps by the researches of these philosophers.

There are six great eras in electro-chemical science:—1. Its first discovery by Galvani; 2. Volta's discovery of the contact of dissimilar metals disturbing the electric equilibrium; 3. Volta's invention of the pile; 4. The *chemical* power of this instrument, first observed by Messrs. Carlisle and Nicholson, in the decomposition of water; 5. The identity of these chemical effects with those producible by common electricity, first discovered and demonstrated by Dr. Wollaston, in his admirable

"Experiments on the Chemical Production and Agency of Electricity;" and, lastly, The general laws of electro-chemical decomposition and transfer, revealed by Sir H. Davy, in a series of memoirs equally remarkable for genius and industry. It is but justice to this philosopher to state, that the germ of his most splendid discoveries was manifestly formed and exhibited, immediately after the construction of the pile was announced. Volta's celebrated letter, descriptive of his invention, is dated Como, March 20, 1800; it was published in the Philosophical Transactions, in the autumn of that year; and in Nicholson's Journal for September of the same year, we have an important communication from Sir H. Davy, then superintendant of the Pneumatic Institution at Bristol.

Mr. Carlisle having been favoured by Sir Joseph Banks with a private perusal of Volta's letter, constructed a pile; and in the beginning of May, assisted by Mr. Nicholson, made several experiments on the decomposition of water, and the reddening of litmus by its means; but out of delicacy to the Professor of Pavia, these were not published till July. Mr. Nicholson, in a masterly account of Volta's discovery, Mr. Carlisle's, and his own, says, "We had been led by our reasoning on the first appearance of hydrogen, to expect a decomposition of the water; but it was with no little surprise that we found the hydrogen extricated at the contact with one wire, while the oxygen fixed itself in combination with the other wire, at the distance of almost two inches. This new fact still remains to be explained, and seems to point at some general law of the agency of electricity in chemical operations."

"Struck," says Sir H. Davy, "with the curious phenomena noticed by Messrs. Nicholson and Carlisle, namely, the apparent separate production of oxygen and hydrogen from different wires, or from different parts of the water completing the galvanic circle, my first researches were directed towards ascertaining, if oxygen and hydrogen could be separately produced from quantities of water, not immediately in contact with each other." He then proceeds to describe very ingenious and decisive experiments, in which he produced the distinct evolution of oxygen and hydrogen, from water contained in two separate glasses, even when the communication was made between them, through dead muscular fibre, through his own body, or even through three persons. He next submits water, deprived of its loosely combined oxygen by boiling, to the voltaic pile, and obtains its two constituents in a pure state.

"Reasoning," says he, "on this separate production of oxygen and hydrogen from different quantities of water, and on the experiments of Mr. Henry, junior, on the action of galvanic electricity on different compound bodies, I was led to suppose, that the constituent parts of such bodies (supposing them immediately decomposable by the galvanic influence), might be separately extricated from the wires, and in consequence *obtained distinct from each other.*" After submitting solution of potash to the voltaic powers of 100 pairs of small plates, without obtaining the expected decomposition, he observes, "Surprised at these results, which proved that no decomposition of potash had taken place, and that that substance, in this mode of operating, only enabled the galvanic influence to extricate oxygen and hydrogen more rapidly from water, I was induced to operate upon this substance in the way of direct communication." Still only the water was decomposed, as we might now expect. He finally describes the decomposition of water of ammonia, as well as sulphuric and nitric acids, and concludes by correcting an error into which Dr. Henry had fallen, concerning a supposed decomposition of potash. "If," says he, "the ratio between the quantities of oxygen and hydrogen produced from the different wires, be always the same, whatever substances are held in solution by the water connected with them, this nascent hydrogen will become a powerful and accurate instrument of analysis."

Dr. Wollaston coated the middle of a very fine silver wire, for two or three inches, with sealing-wax, and by cutting it through in the middle of the wax, exposed a section of the wire. The two coated extremities of the wire thus divided, were immersed in a solution of sulphate of copper, placed in an electric circuit between the two conductors of a cylindrical machine; and sparks taken at 1-10th of an inch distance were passed by means of them through the solution. After 100 turns of the machine, the wire which communicated with (what is called) the negative conductor, had a precipitate formed on its surface, which, on being burnished, was evidently copper; but the opposite wire had no such coating.

Upon reversing the direction of the current of electricity, the order of the phenomena was of course reversed; the copper being shortly redissolved by assistance of the oxidating power of positive electricity, and a similar precipitate formed on the opposite wire.

A similar experiment, made with gold wires $\frac{1}{100}$ of an inch diameter, in a solution of corrosive sublimate, had the same success.

If a piece of zinc and a piece of silver have each one extremity immersed in the same vessel, containing sulphuric or muriatic acid diluted with a large quantity of water, the zinc is dissolved, and yields hydrogen gas by decomposition of the water; the silver not being acted upon, has no power of decomposing water; but whenever the zinc and silver are made to touch, or any metallic communication is formed between them, hydrogen gas is also produced at the surface of the silver.

has no effect.

Experiments analogous to the former, and equally simple, may also be made with many metallic solutions. If, for instance, the solution contains copper, it will be precipitated by a piece of iron, and will appear on its surface. Upon silver merely immersed in the same solution, no such effect is produced; but as soon as the two metals are brought into contact the silver receives a coating of copper.

In the explanation of these experiments, says Dr. Wollaston, it is necessary to advert to a point established by means of the electric pile. We know that when water is placed in a circuit of conductors of electricity between the two extremities of a pile, if the power is sufficient to oxidate one of the wires of communication, the wire connected with the opposite extremity affords hydrogen gas. Since the extrication of hydrogen in this instance is seen to depend on electricity, it is probable that, in other instances, electricity may be also requisite for its conversion into gas. It would appear, therefore, that in the solution of a metal, electricity is evolved during the action of the acid on it; and that the formation of hydrogen gas, even in that case, depends on a transition of electricity between the fluid and the metal.

We see, moreover, in the experiments with zinc, that this metal, without contact of any other, has the power of decomposing water; and we can have no reason to suppose that the contact of the silver produces any new power, but that it serves merely as a conductor of electricity, and thereby occasions the formation of hydrogen gas. In the next experiment, the iron by itself has the power of precipitating copper by means, it is presumed, of electricity evolved during its solution; and here likewise the silver, by conducting the electricity, acquires the power of precipitating the copper in its metallic state.

The explanation now given, with regard to these voltaic combinations of single pairs, receives additional confirmation from the above comparative experiments with common electricity. These show, that the same transfer of chemical power, and the same apparent reversion of the usual order of chemical affinities in the precipitation of copper by silver, may be effected by a common electrical machine.

The chemical agency of common electricity is thus proved to be the same with the power excited by chemical means; but since a difference had been observed in the comparative facility with which the pile of Volta decomposes water, and produces other effects of oxidation and deoxidation of bodies exposed to its action, Dr. Wollaston was at pains to remove this difficulty, and succeeded in producing the decomposition of water; but when he considered that the decomposition must depend on duly proportioning the strength of the charge of electricity to the quantity of water, and that the quantity exposed to its action at the surface of communication, depends on the extent of that surface; by reducing this, he effected the decomposition of water by a much smaller machine. Having procured a small wire of fine gold, and given it as fine a point as he could, he inserted it into a capillary glass tube, and after heating the tube, so as to make it adhere to the point, and cover it in every part, he gradually ground it down, till with a pocket lens he could discover that the point of the gold was exposed.

The success of this method exceeding his expectations, he coated several wires in the same manner, and found, that when sparks from the conductors before mentioned were made to pass through water, by means of a point so guarded, a spark passing to the distance of one-eighth of an inch would decompose water, when the point exposed did not exceed 1-700th of an inch in diameter. With another point, which he estimated at 1-1500th, a succession of sparks 1-20th of an inch in length afforded a current of small bubbles of air. But in every way in which he tried it, he observed that each wire gave both oxygen and hydrogen gas, instead of their being formed separately as by the electric pile.

He is inclined to attribute the difference in this respect to the greater intensity with which it is necessary to employ common electricity; for that positive and negative electricity, so excited, have each the same chemical power as they are observed to have in the electric pile, may be ascertained by other means.

In the precipitation of copper by silver, an instance of deoxidation by negative electricity has been mentioned: the oxidating power of positive electricity may be also proved by its effect on vegetable colours.

Having coloured a card with a strong infusion of litmus, he passed a current of electric sparks along it, by means of two fine gold points, touching it at the distance of an inch from each other. The effect, as in other cases, depending on the smallness of the quantity of water, was most discernible when the card was nearly dry. In this state a very few turns of the machine were sufficient to occasion a redness at the positive wire, very manifest to the naked eye. The negative wire being afterwards placed on the same spot, soon restored it to its original blue colour. By the voltaic pile, the same effects are produced in a much less time.

Dr. Wollaston concludes, that all the differences discoverable in the effects of galvanic a voltaic pile of 50 or 100 pairs, being made to touch the brass cap of the electroscope, will cause the gold leaves instantly to diverge with vitreous electricity; a wire connected with the copper end will make them diverge with resinous electricity; but a wire from the middle of the pile will have no effect on the electroscope.

If wires of platinum from the opposite extremities of the pile be introduced into any solution of a neutral salt containing acid, united to alkaline, earthy, or common metallic matter; acid matter will collect round the vitreously electrified or positive surface; alkali, earth, or oxide, round the resinously electrified or negative surface. If two separate vessels are employed to contain the solution, connected by moist asbestos, it is found that the acid collected in the vessel containing the wire positively electrified, will be in definite proportion to the matter collected in the other cup; that is, it will form with it a neutrosaline compound. If aqueous muriatic acid be acted on by the wires, hydrogen will separate at the negative surface, and chlorine at the positive.

The preceding may be regarded as the elementary and fundamental facts discovered with regard to voltaic electricity. Before describing its greater and more complex operations, we shall give an account of the various modifications of the apparatus.

In the original trough of Cruikshanks, the contact of every pair of copper and zinc plates was secured by soldering their surfaces together. Each compound metallic plate being of a square form, was fixed tight by cement into grooves cut in the sides, and across the bottom of the oblong mahogany box. The cells between every pair of plates were filled with the neutrosaline or acidulous exciting liquid. The difficulty of cleaning the surfaces of the plates in this construction, and an idea that the quantity of electricity was proportional to the zinc surface exposed to oxidizement, led to the revival of the *couronnes des tasses* arrangement. In this, the square plates of zinc and copper in each pair were placed parallel to each other, at a distance of about half an inch, and soldered together at the middle of one edge by a rectangular narrow arc of copper. Each pair was fixed parallel to the preceding pair, and at a distance corresponding to the width of the cells in the porcelain trough, by screwing their rectangular arcs to a rod of baked and well varnished wood. Ten or a dozen pairs of plates, from four to six inches diameter each, could thus at once be conveniently plunged into, or removed from, the exciting liquid. By connecting together a series of these troughs, a very powerful battery was obtained. More recently, Dr. Wollaston has rendered it probable that the igniting in-

nishing power of ignition, exhibited by his pair of small plates, seems to warrant that conclusion.

For compactness of structure, and convenience in use, I prefer the original mahogany box, and soldered pairs of plates of Cruikshanks. The zinc surfaces may be easily freed from adhering oxide, by a steel scraper of a proper shape. Nor do I find, that this form of apparatus is notably inferior, in chemical effect, to the separate plates of the same size in porcelain cells. Dr. Hare of Philadelphia has lately contrived an ingenious modification of Dr. Wollaston's single igniting pair, which, from its great power of exciting heat, and its small electric intensity, he has styled a calorimeter.

When the plates are very large, they must be constructed on the plan of the porcelain trough. In this way, Mr. Children arranged his gigantic battery, the most magnificent voltaic apparatus which the world has hitherto seen. It consisted of 20 pairs of copper and zinc plates, each plate six feet long and two feet eight inches broad. Each pair is joined at top by ribands of lead, and has a separate wooden cell. They are suspended from a beam of wood, and having counterpoises, are easily raised or let down into their cells. The power of this battery was first tried on 2d July, 1813. The cells were filled with water 60 parts, and a mixture of nitric and sulphuric acid one part, which was gradually increased till the quantity of acid was doubled. Conductors of lead conveyed the electricity to an adjoining shade, in which the experiments were made. The power of the battery was prodigious. It ignited six feet in length of thick platinum wire; but could not ignite an equal length of smaller platinum wire. This difference was ingeniously ascribed by Dr. Wollaston, to the cooling influence of the air acting more efficaciously on the slender mass of metal. Platinum, in shorter lengths, was fused with great facility. Iridium was melted into a globule, and proved to be a brittle metal. The compound ore of iridium and osmium was likewise fused, but not perfectly. Charcoal kept at a white heat, in chlorine and chlorocarbonous gases, produced no change on them. Neither tungsten nor uranium was any way changed by this vast battery.

At a very early period of his illustrious electro-chemical career, Sir H. Davy invented various voltaic constructions, in which either only one metal was employed, or no metallic body at all. Among the *scientific news* inserted in the Philosophical quarto Journal for May 1801, we are told that he had formed piles, consisting of the single metals, silver, copper, zinc, and lead; and that one of the arrangements was, a plate of metal, cloth, soaked in dilute nitrous acid, cloth soaked in water, and cloth soaked in solution of sulphuret of potash; then another plate of the same metal, and the three cloths as before. It is added, that if a trough be used with cells, and the separation between the acid and the sulphuret of potash be made by a plate of horn, instead of the cloth imbibed with water, the two fluids may be connected by a slip of wetted cloth, hung over the upper edge of the horn. This will complete the communication, without occasioning any mixture, because water is lighter than any of the other fluids. A full account of these new and very curious arrangements was published in the Philosophical Transactions for the above year, and is copied into the December Number of Nicholson's Journal.

Silver or copper, in the above construction, forms an electrical apparatus, which, with a series of fifty plates, will give shocks. When the structure is that of a pile, the cloth impregnated with the densest solution should be undermost in each alternation; and solution of common salt in the middle.

The following tables contain some series, which form voltaic electrical combinations, arranged in the order of their powers; the most active substances being named first in each column.

TABLES by Sir H. Davy, of some Electrical Arrangements, which, by combination, form voltaic batteries, composed of two conductors, and one imperfect conductor.

The metal, first named, is positive, in reference to all those that follow it:—

With ordinary acids:

Potassium and its amalgams, barium and its amalgams, amalgam of zinc, zinc, amalgam of ammonium, cadmium, tin, iron, bismuth, antimony, lead, copper, silver, palladium, tellurium, gold, charcoal, platinum, iridium, rhodium.

With alkaline solutions:

The metals of the alkalis and their amalgams, zinc, tin, lead, copper, iron, silver, palladium, gold, platinum, &c.

With the solutions of hydrosulphurets:

Zinc, tin, copper, iron, bismuth, silver, platinum, palladium, gold, charcoal. *Phil. Trans.*, 1826.

TABLE II.—*Of some Electrical Arrangements, consisting of one conductor and two imperfect conductors.*

Solution of sulphur and potash	Copper	Nitric acid.
of potash	Silver	Sulphuric acid.
of soda	Lead	Muriatic acid.
	Tin	Any solution containing acid.
	Zinc	
	Other metals	
	Charcoal	

The metals having the strongest attraction for oxygen, are the metals which form the positive pole, in all cases in which the fluid menstrua act chemically, by affording oxygen; but when the fluid menstrua afford sulphur to the metals, the metal having the strongest attraction for sulphur, under the existing circumstances, determines the positive pole. Thus, in a series of copper and iron, introduced into a porcelain trough, the cells of which are filled with water, or with acid solutions, the iron is positive, and the copper negative; but when the cells are filled with solutions of sulphur and potash, the copper is positive, and the iron negative.

In all combinations in which *one* metal is concerned, the surface opposite the acid is negative, while that in contact with the solution of alkali and sulphur, or of alkali, is positive.

Every one who has a perception of the beautiful in philosophical research, must regard this important law, discovered by Sir H. Davy, with admiration. It promises to lead us eventually into the mysteries of electro-chemical action, farther than any general principle hitherto established. It gives another fine analogy between electricity and heat. For as the disengagement of the latter power is always proportional to the intensity of chemical combination, so in the present case we see, that the intenser chemical action is connected with the evolution of positive electricity, while the feebler is associated with the negative. The positive electricity, if we judge from the appearance of its light, is the more active of the two; and it is known to promote the most intense combinations of bodies, viz. those with chlorine, iodine, and oxygen.

The divergence of the leaves in the gold-leaf electroscope, and most exactly the separation of the ball and disc in the electrometer of Coulomb, are proportional to the resilient force, or intensity, of the electrical agent. Hence the repetition of a series of moderate-sized voltaic plates, indicates the same repelling energy on these instruments, as the same series of much larger plates. With regard to imperfect conductors, like the human body, or neutrosaline solutions, the effects, namely, the shock, and transfer of the elements, are also proportional to the electrical intensity, or electroscopic indications. For these purposes, we need not enlarge the plates beyond a certain size, which is relative to the conducting power of the substances through which the electrical energy is to be transmitted. But with excellent conductors, like charcoal and the metals, the *quantity* of electricity, and not its state of *condensation*, is to be regarded. The intensity is essential, to enable it to communicate electrical polarities to a series of material liquid molecules, or to force its way, so to speak, through the animal frame. But the same intensity is altogether superfluous relative to metallic objects. To operate changes on these, we must favour the evolution of a great mass of electrical power, by using plates of extensive areas.

To prove the justness of these views, let us bring into action, by the same exciting liquid, a clean battery of 20 pairs of 1 inch, and 20 pairs of 10 inch plates. On exposing a small column of water, in a glass tube, first to the one battery and then to the other, or on connecting, with the two hands, first the extremities of the one and then those of the other, we shall perceive the evolution of gases, or the shock, to be nearly equal. While the energy of the larger battery is acting on the water or human body, let two little cylinders of charcoal, connected with the ends of the trough by metallic wires, be made to touch each other, the electrical excess will be sufficient to produce vivid ignition at the points of contact. Silver leaf may be substituted for the charcoal, with a similar effect. The little battery, however, exhausts its energy on the column of water. When thus employed, it will give scarcely any sensation to the fingers, and produce no effect on the charcoal or leaf. Even the battery of Mr. Children, which, after igniting great lengths of platinum wire, to a whiteness insupportable to the eye, fused it into globules; and which emitted from charcoal a light more dazzling than the sunbeam, had no more effect on water, and the living body, than an equal series of little plates.

As Mr. Children's battery is the most powerful in the world, in *calorific effect*, so that of 2000 pairs of plates, of 32 inches each, furnished by the subscription of a few patrons of science connected with the Royal Institution, is the most powerful yet constructed in *electro-chemical intensity*. The whole surface is 128,000 square inches.

This battery, when the cells were filled with 60 parts of water, mixed with one part of nitric acid, and one of sulphuric acid, afforded a series of brilliant and impressive effects. When pieces of charcoal, about an inch long, and one-sixth of an inch in diameter, were brought within 1-30th or 1-40th of an inch of each other, a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness; and by drawing back the points a little from each other, a constant discharge took place, through the heated air, in a space equal at least to four inches, producing a most brilliant ascending arch of light, expanded and conical in the middle. When any substance was introduced into this arch, it instantly became ignited.

Platinum melted in it, like wax in the flame of a common candle. Quartz, the sapphire, magnesia, lime, all entered into fusion. Fragments of diamond, and points of charcoal and plumbago, rapidly disappeared, and seemed to evaporate in it, even when the connexion was made in a receiver exhausted by the air-pump; but there was no evidence of their having previously undergone fusion.

When the communication between the points, positively and negatively electrified, was made in air rarefied in the receiver of the air-pump, the distance at which the discharge took place increased as the exhaustion proceeded; and when the atmosphere in the vessel supported only an inch of mercury in the barometrical gauge, the sparks passed through a space of nearly half an inch. By making the points recede from each other, the discharge was made through 6 or 7 inches, producing a most beautiful coruscation of purple light; the charcoal became intensely ignited, and some platinum wire attached to it, fused with brilliant scintillations, and fell in large globules upon the plate of the pump. All the phenomena of chemical decomposition were produced with intense rapidity, by this combination. When the points of charcoal were brought near each other in non-conducting fluids, such as oils, ethers, and chloridic compounds, brilliant sparks occurred, and elastic matter was generated. Such, indeed, was the electric intensity, that sparks were produced, even in good imperfect conductors, such as the nitric and sulphuric acids.

When the two conductors from the ends of the combination were connected with a Leyden battery, one with the internal, the other with the external coating, the battery instantly became charged, and on removing the wire, and making the proper connexions, either a shock or a spark could be perceived; and the least possible time of contact was sufficient to renew the charge to its full intensity.

The general facts of the connexion of the increase of the different powers of the battery with the increase of the number and surface of the series, are very distinct; but to determine the exact ratio of the connexion, is a problem not easy of solution.

MM. Gay Lussac and Thenard announced, that the power of chemical decomposition increases only as the cube root of the number of plates; but their experiments were made with parts of piles, says Sir H. Davy, very unfavourable for gaining accurate results. In various trials made by him, with great care, in the laboratory of the Royal Institution, the results were altogether different.

The batteries employed were parts of the above great combination, carefully insulated, and similarly charged; arcs of zinc and silver presenting equal surfaces, arranged in equal glasses, filled with the same kind of fluid, were likewise used; and the tubes were precisely similar, and filled with the same solution of potash. In these experiments, 10 pairs of plates produced 15 measures of gas; 20 pairs produced in the same time 49; again, 10 pairs produced five measures; 40 pairs in the same time produced 78 measures. In experiments made with arcs, and which seemed unexceptionable,

4 pairs produced 1 measure of gas.
12 in the same time $9\frac{1}{10}$
When 6 produced . . 1
30 . . . 24.5.

Now, these quantities are nearly as the squares of the number of pairs.

In batteries whose plates have equal areas, the calorific power has been said to be as the number. Sir H. Davy, however, found that when the surface of each was 100 square inches,

10 pairs ignited 2 inches of plat. wire 1-80th of an inch.
20 do. do. 5 inches do. do.
40 do. do. 11 inches do. do.

The results of experiments on higher numbers were not satisfactory, for 100 pairs, of 32 square inches each ignited three inches of platinum wire 1-70th of an inch; and 1000 ignited only 13 inches. The charges of exciting acid were similar in both cases.

The ratio between the increase of calorific power, and increased area of the plates, is probably greater than even the square. For 20 pairs of plates, containing each two square feet, did not ignite one-sixteenth as much wire, as 20 pairs containing each eight square feet; the acid employed being of the same strength in both cases. But great difficulties occur to ensure accuracy in experiments on extensive and powerful batteries.

In Sir H. Davy's great Bakerian Lecture on the chemical agencies of electricity, published in the Phil. Trans. for 1807, and most deservedly crowned by the National Institute of France with the Napoleon prize, he amply demonstrated that acids, which are electrically negative, with respect to alkalis, metals, and earths, are separated from these bodies in the voltaic circuit at the positive pole; and alkalis, metals, and earths, are separated from acids at the negative surface. He showed further, that such are the attracting powers of these surfaces, that acids are transferred through alkaline solutions, and alkalis through acid solutions, to the poles where they have their points of repose. This was exhibited by making a combination of three agate cups, one containing sulphate of potash, one weak nitric acid, and a third distilled water. The three were connected by asbestos moistened in pure water, in such a manner that the surface of the acid was lower than the surface of the fluid in the other two cups. When two wires of platina from a powerful voltaic apparatus, are introduced into the two extreme cups, the solution of the salt being positively electrified, a decomposition took place, and in a certain time a portion of potash was found dissolved in the cup in contact with the negative wire, though the fluid in the middle cup was still sensibly acid.

Such are the chemico-analytical powers of electricity, that not even insoluble compounds are capable of resisting their energy; for glass, sulphate of barytes, fluor spar, gypsum, marble, &c. when moistened and placed in contact with electrified surfaces from the voltaic apparatus, are sensibly acted on, and the alkaline, earthy, or acid matter, slowly carried to the poles in the common order. Not even the most solid aggregates, nor the firmest compounds, are capable of resisting this mode of attack. Its operation is slow, but the results are certain, and sooner or later, by means of it, bodies are resolved into simpler forms of matter.

Till Sir H. Davy established the grand law of electro-chemical decomposition, that metals, inflammable bodies, alkalis, earths, and oxides, are determined to the negative surface or pole, and oxygen, chlorine, iodine, and acids, to the positive pole, it had been imagined that various substances might be generated from pure water by means of electricity, such as potash, soda, and muriatic acid. A strict investigation of the circumstances under which these substances appeared, led him to discover that they were always furnished from the vessels, or from impurities in the water, and enabled him to determine the general principles of electrical decomposition, and to apply this power to the resolution of several species of matter of unknown nature into their elements, namely, the alkalis, earths, boracic and muriatic acids, &c.

The intimate relation between the electrical and chemical changes, is evident likewise in the general phenomena of the battery. The most powerful voltaic combinations are formed by substances that act chemically, with most energy upon each other. Such substances as undergo no chemical changes in these combinations exhibit no electrical powers. Thus, zinc, copper, and nitric acid, form a powerful battery; while silver, gold, and water, which do not act chemically on each other, produce, in series of the same number, no perceptible effect. These circumstances, in the infancy of galvanic research, led to the belief that the electrical phenomena were entirely the results of chemical changes; and that as heat was produced by chemical action, under common circumstances, so electricity resulted from it under other circumstances.

This generalization seems, however, to be incorrect. Zinc and copper, different metals and oxalic acid, different metals and sulphur or charcoal, exhibit electrical effects after mere contact, and that in cases when not the slightest chemical change can be observed. If in these experiments, indeed, chemical phenomena are produced by the action of menstrua, all electrical effects immediately cease.

The source of action of the voltaic apparatus seems to depend upon causes similar to those which produce the accumulation in the Leyden battery, namely, *that* influence at a distance, or electrical induction, which was fully treated of at the commencement of this article. But its continuous action, or electro-motion, is connected with the decomposition of the chemical menstrua between the plates. Each plate of zinc, in the first place, is made positive, and each plate of copper negative, by contact; and all the plates are so arranged with respect to each other, as to have their electricities exalted by induction, so that every single polar arrangement heightens the electricity of every other polar arrangement: and hence the accumulation of power, or intensity, must increase with the number of the series. When the battery is connected in a circle, the effects are demonstrated by its constant exhibition of chemical agencies, and the powers exist as long as there is any menstruum to decompose. But when it is insulated, and the extreme poles of zinc and copper are unconnected, no effects whatever are perceived to take place, no chemical changes go on, and it exhibits its influence only by communicating very weak charges to the electrometer; the zinc termination of the pole communicating a positive charge, the copper termination a negative charge.

A beautiful experiment of Sir H. Davy's proves, that each plate of the most oxidable metal in the apparatus, is in the relation of positive, and that each plate of the least oxidable is in the relation of negative, while every series is possessed of similar and equal polarity. Forty rods of zinc of the same size, connected with forty silver wires, precisely similar, were introduced, in the regular order, into similar glasses, filled with a solution of muriate of ammonia, rendered slightly acidulous by muriatic acid. As long as the extreme parts remained unconnected, no gas was disengaged from the silver, and the zinc was scarcely acted upon. When they were connected, all the plates of zinc were dissolved much more rapidly, and hydrogen gas was evolved from every silver wire. In another experiment, in which several of these wires, at equal distances, were introduced into small glass tubes, it was found that equal quantities of hydrogen were produced.

There are no fluids known, except such as contain water, which are capable of being made the medium of connexion between the metals or metal of the voltaic apparatus; and it is probable that the power of water to receive double polarities, and to evolve oxygen and hydrogen, is necessary to the constant operation of the connected apparatus. We may suppose also, that acids or saline bodies increase the action, by affording elements which possess opposite electricities to each other, when mutually excited. The action of the chemical menstrua exposes continually new surfaces of metal; and the electrical equilibrium may be conceived, in consequence, to be alternately destroyed and restored, the changes taking place in imperceptible portions of time.

We may show the manner in which aqueous fluids propagate electrical polarity among their particles, by a very simple experiment. Cut narrow filaments of tin-foil into lengths of almost half an inch, and place them in a line on the surface of an oblong trough of water. On plunging into the water, at each end, wires connected with the two extremities of an active voltaic battery, the metallic filaments will immediately acquire polarity. Their positive and negative poles will become regularly opposed to each other; the first depositing oxide, and the last evolving hydrogen. The analogy with magnetic actions is here very complete.

That the decomposition of the chemical agents is connected with the energies of the pile, is evident from all the experiments that have been made. No sound objection has been urged against the theory, that the contact of the metals destroys the electrical equilibrium, and that the chemical changes restore it; and, consequently, that the action exists as long as the decompositions continue.

Volta called his admirable invention an electro-motive apparatus, founding his theory of its operation upon the Franklinian idea of an electrical fluid, for which certain bodies have stronger attractions than others. He conceived that in his pile, the upper plate of zinc attracts electricity from the copper, the copper from the water, the water again from the next plate of zinc, the next plate of zinc from the next plate of copper, and so on. This hypothesis applies happily to most of the phenomena of the action of the insulated pile, and the pile connected by either of its extremities with the ground; but does not explain with the same facility the powers of the apparatus connected in a circle, in which each plate of zinc must be supposed to have the same quantity of electricity as each plate of copper; for it can only, as Sir H. Davy justly observes, receive as much as the copper can give, unless indeed the phenomena of the circular apparatus be considered as depending upon the constant and rapid circulation of the natural quantity of electricity in the different series, which requires the proof of a constant power to attract electricity from one body, at the same time that it is given off to another. But the investigations of Coulomb and Poisson, already detailed, fully demonstrate that electricity is not distributed among different species of matter by any kind of elective attraction.

Platinum melts with more facility at the positive than at the negative pole, when it is connected with charcoal; but with sulphuric acid, it becomes red-hot, only when it is negative, and the acid positive. In the calorific effect in general, charcoal is most easily ignited, next iron, platinum, gold, then copper, and lastly, zinc.

See Sir H. Davy's Elements, and M. Biot's Traité de Physique, tome ii. chapitre 16; Effets Chimiques de l'Appareil electromoteur.

We shall retain the title GALVANISM, out of respect to its discoverer, and place under it some details concerning the influence of this form of electricity on living bodies.

ELECTRO-MAGNETISM. The name given to a class of very interesting phenomena, first observed by M. Oersted of Copenhagen in the winter of 1819-20, and which have since received great illustration from the labours of M. Ampère, M. Arago, Sir H. Davy, Dr. Wollaston, Mr. Faraday, M. de la Rive, and several other philosophers. The nature and limits of this Dictionary will allow me to give merely a short outline of the fundamental facts.

Let the opposite poles of a voltaic battery be connected by a metallic wire, which may be left of such length as to suffer its being bent or turned in various directions. This is the conjunctive wire of M. Oersted. Let us suppose that the rectilinear portion of this wire is extended horizontally in the line of the magnetic meridian. If a freely suspended compass needle be now introduced, with its centre *under* the conjunctive wire, the needle will instantly deviate from the magnetic meridian; and it will decline towards the *west*, under that part of the conjunctive wire which is nearest the negative electric pole, or the copper end of the voltaic apparatus. The amount of this declination depends on the strength of the electricity, and the sensibility of the needle. Its *maximum* is 90°.

We may change the direction of the conjunctive wire, out of the magnetic meridian, towards the east or the west, provided it remains above the needle, and parallel to its plane, without any change in the above result, except that of its amount. Wires of platinum, gold, silver, brass, and iron, may be equally employed; nor does the effect cease though the electric circuit be partially formed by water. The effect of the conjunctive wire takes place across plates of glass, metal, wood, water, resin, pottery, and stone.

If the conjunctive wire be disposed horizontally *beneath* the needle, the effects are of the same nature as those which occur when it is *above* it; but they operate in an inverse direction; that is to say, the pole of the needle under which is placed the portion of the conjunctive wire which receives the negative electricity of the apparatus, declines in that case towards the *east*.

To remember these results more readily, we may employ the following proposition: *The pole* ABOVE *which the negative electricity enters, declines towards the* WEST; *but if it enters* BENEATH *it, the needle declines towards the* EAST.

If the conjunctive wire (always supposed horizontal) is slowly turned about, so as to form a gradually increasing angle with the magnetic meridian, the declination of the needle increases, if the movement of the wire be towards the line of position of the disturbed needle; it diminishes, on the contrary, if it recede from its position.

When the conjunctive wire is stretched along-side of the needle in the same horizontal plane, it occasions no declination either to the east or west; but it causes it merely to incline in a vertical line, so that the pole adjoining the negative influence of the pile on the wire dips when the wire is on its west side, and rises when it is on the east.

If we stretch the conjunctive wire, either above or beneath the needle, in a plane perpendicular to the magnetic meridian, it remains at rest, unless the wire be very near the pole of the needle; for, in this case, it rises when the entrance takes place by the west part of the wire, and sinks when it takes place by the east part.

When we dispose the conjunctive wire in a vertical line opposite the pole of the needle, and make the upper extremity of the wire receive the electricity of the negative end of the battery, the pole of the needle moves towards the *east*; but if we place the wire opposite a point betwixt the pole and the middle of the needle, it moves to the *west*. The phenomena are presented in an inverse order, when the upper extremity of the conjunctive wire receives the electricity of the positive side of the apparatus.

It appears from the preceding facts, says M. Oersted, that the electric conflict (action) is not enclosed within the conducting wire, but that it has a pretty extensive sphere of activity round it. We may also conclude from the observations, that this conflict acts by revolution; for without this supposition we could not comprehend how the same portion of the conjunctive wire, which, placed *beneath* the magnetic pole, carries the needle towards the east, when it is placed *above* this pole, should carry it towards the west. But such is the nature of the circular action, that the movements which it produces take place in directions precisely contrary to the two extremities of the same diameter. It appears also, that the circular movement, combined with a progressive movement in the direction of the length of the conjunctive wire, ought to form a kind of action, which operates *spirally* around this wire as an axis. For further information, Mr. Faraday's able paper, in the Journal of Science, xii. 74. may be consulted; as also M. Ampère's several ingenious memoirs in the Annales de Chimie et de Physique, vol. xv. *et seq.* See Thermo-electro-magnetism.

ELECTRUM. See Ores of Gold.

ELEMENTS. A term used by the earlier chemists, nearly in the same sense as the moderns use the term *first principle*. The chief, and indeed very essential difference between them is, that the ancients considered their elements as bodies possessing absolute simplicity, and capable of forming all other bodies by their mutual combination; whereas the first principles of the moderns are considered as simple, merely in respect to the present state of the art of analyzing bodies. See the Introduction.

ELEMI. A resin, which exudes from incisions made, in dry weather, through the bark of the *amyris elemifera*, a tree which grows in America. It is wrapped in flag leaves, in long roundish cakes, semitransparent, and of a yellow colour. It has a faint fragrance. Elemi has an acrid taste, and an odour partaking both of camphor and lemon. It contains clear resin soluble in cold alcohol, 60; white opaque matter soluble in boiling alcohol, 24·00; volatile oil, 12·5; bitter extractive, 2·0; impurities, 1·50. Elemi is sometimes adulterated with the resin of the pinus australis, which is easily recognized by its entire solubility in cold alcohol. *Jour. de Pharm.* for Aug. 1822.

ELIQUATION. An operation by means of which a more fusible substance is separated from another which is less fusible. It consists in the application of a degree of heat sufficient to fuse the former, but not the latter.

ELUTRIATION. This word is used by chemists to denote the process of washing, which carries off the lighter earthy parts, while the heavier metallic parts subside to the bottom.

EMERALD. This genus contains two species, the prismatic and rhomboidal.

1. *Prismatic Emerald*, Euclase of Haüy. Its colours are green, of various shades, and sometimes sky-blue. It is found only crystallized. The primitive form is a prism of 133° 24'. Its secondary forms are, an oblique four-sided prism, variously modified by acuminations and truncations. The lateral planes are more or less longitudinally streaked, giving the prisms a reed-like appearance. Lustre splendent. Cleavage perfect, in the direction of the smaller diagonals of the prism. Fracture small conchoidal. Fragments tabular. Transparent. Refracts double. Harder than quartz, but softer than topaz. Easily frangible. Sp. gr. 2·9 to 3·3. Loses transparency, and then melts, before the blowpipe. Its constituents are 35 to 36 silica, 18 to 19 alumina, 14 to 15 glucina, 2 to 3 iron, and 27 to 31 loss. The last is chiefly water, and in some measure alkali. Found in Peru and Brazil. It is a beautiful mineral, but too brittle for jewellery.

2. *Rhomboidal Emerald*, of which there are two sub-species, the precious emerald and the beryl. Precious emerald is well characterized by its emerald-green colour, of various depths. It is generally crystallized. The primitive form is an equiangular six-sided prism, on which various truncations are found. The lateral planes are smooth; the terminal planes rough. Lustre splendent. Cleavage straight and four-fold. Fracture imperfect conchoidal. Transparent. Moderate double refraction. Nearly as hard as topaz. Sp. gr. 2·6 to 2·77. Heated to a moderate degree, it becomes of a blue colour, but recovers its tint on cooling. At a high heat, it fuses into a white vesicular glass. Its constituents are, silica 64·5, alumina 16, glucina 13, oxide of chrome 3·25, lime 1·6, water 2. Klaproth found 1 of oxide of iron. It occurs in drusy cavities, along with iron pyrites, calcareous spar, and quartz, in veins that traverse clay-slate. The most beautiful emeralds come from Peru. As a gem, it is valued next to the ruby. See Beryl, in its alphabetical place.

EMERY. A sub-species of rhomboidal corundum. Its colour is intermediate between greyish-black and bluish-grey. It occurs massive and disseminated, and also in granular concretions. Lustre glistening and adamantine. Fracture fine-grained, uneven. Translucent on the edges. So very hard as to scratch topaz. Difficultly frangible. Sp. gr. 4·0. Its constituents are 86 alumina, 3 silica, 4 iron, and 7 loss. In Saxony, it occurs in beds of talc and steatite. It occurs abundantly in the Isle of Naxos, and also at Smyrna. It is used for polishing hard minerals and metals. Its fine powder is obtained by trituration and elutriation.

EMETIN. Digest ipecacuan root, first in ether and then in alcohol. Evaporate the alcoholic infusion to dryness, redissolve in water, and drop in acetate of lead. Wash the precipitate, and then, diffusing it in water, decompose by a current of sulphuretted hydrogen gas. Sulphuret of lead falls to the bottom, and the emetin remains in solution. By evaporating the water, this substance is obtained pure.

Emetin forms transparent brownish-red scales. It has no smell, but a bitter acrid taste. At a heat somewhat above that of boiling water, it is resolved into carbonic acid, oil, and vinegar. It affords no ammonia. It is soluble both in water and alcohol, but not in ether; and uncrystallizable. It is precipitated by protonitrate of mercury and corrosive sublimate, but not by tartar emetic. Half a grain of emetin acts as a powerful emetic, followed by sleep; six grains vomit violently, and produce stupor and death. The lungs and intestines are inflamed.' Pelletier and Magendie, *Ann. de Chimie et de Physique*, iv. 172.

In the 24th volume of the *Annales de Chim. et Phys.*, MM. Dumas and Pelletier describe an improved process for extracting emetine. The powder of ipecacuanha is digested in water with calcined magnesia. The deposit is thrown on a filter, washed carefully with very cold water, and dried. The emetin is then taken up by alcohol. It may be afterwards combined with an acid, and the salt may be purified with animal charcoal. When the emetin is once more thrown down by magnesia, alcohol redissolves it in a colourless state. Emetin thus obtained is a yellowish white, and pulverulent. The only effect of air is to colour it slightly. It is little soluble in cold water; and somewhat more so in hot. It fuses about 122° F. It is very soluble in alcohol; but not in ether and oils. It is highly alkaline, though acids saturated with it do not afford crystallizable compounds. Gallic acid and nut galls seem to alter it by forming very abundant white precipitates. Subacetate of lead has no effect on it, though it precipitates the coloured emetin, which has, according to M. Magendie, only one-third the activity on the animal frame of the pure substance. Its constituents are carbon 64·57; azote 4·00; hydrogen 7·77; oxygen 22·95.

EMPYREUMA. This term is applied to denote the peculiar smell produced by a considerable heat upon vegetable or animal substances in closed vessels, or when burned under circumstances which prevent the access of air to a considerable part of the mass, and consequently occasion an imperfect combustion, or destructive distillation of the parts so covered up by the rest of the mass.

EMULSION. An imperfect combination of oil and water, by the intervention of some other substance capable of combining with both these substances. The substances are either saccharine or mucilaginous.

ENAMEL. There are two kinds of enamel, the opaque and the transparent. Transparent enamels are usually rendered opaque by adding putty, or the white oxide of tin, to them. The basis of all enamels is therefore a perfectly transparent and fusible glass. The oxide of tin renders this of a beautiful white, the perfection of which is greater when a small quantity of manganese is likewise added. If the oxide of tin be not sufficient to destroy the transparency of the mixture, it produces a semi-opaque glass, resembling the opal.

Yellow enamel is formed by the addition of oxide of lead, or antimony. Kunckel likewise affirms, that a beautiful yellow may be obtained from silver.

Red enamel is afforded by the oxide of gold, and also by that of iron. The former is the most beautiful, and stands the fire very well, which the latter does not.

Oxide of copper affords a green; manganese, a violet; cobalt, a blue; and iron, a very fine black. A mixture of these different enamels produces great variety of intermediate colours, according to their nature and proportion. In this branch of the art, the coloured enamels are sometimes mixed with each other, and sometimes the oxides are mixed before they are added to the vitreous bases.

In the Transactions of the Society of Arts for 1817, a valuable list of receipts for enamel colours is given by Mr. R. Wynn, for the communication of which a premium was awarded. The following are Mr. Wynn's fluxes:—

No. 1.	Red lead,	8 parts.
	Calcined borax,	1½
	Flint powder,	2
	Flint glass,	6
No. 2.	Flint glass,	10
	White arsenic,	1
	Nitre,	1
No. 3.	Red lead,	1
	Flint glass,	3
No. 4.	Red lead,	9½
	Borax not calcined,	5½
	Flint glass,	8
No. 5.	Flint glass,	6
	Flux, No. 2.	4
	Red lead,	8

After the fluxes have been melted, they should be poured on a flag stone, wet with a sponge; or into a large pan of clean water, then dried, and finely pounded in a biscuit-ware mortar for use.

Yellow enamel.

Red lead,	8
Oxide of antimony,	1
White oxide of tin,	1

Mix the ingredients well in a biscuit-ware mortar, and having put them on a piece of Dutch tile in the muffle, make it gradually red-hot, and suffer it to cool. Take of this mixture 1, of flux No. 4. 1½; grind them in water for use. By varying the proportions of red lead and antimony, different shades of colour may be obtained.

Orange.

Red lead,	12
Red sulphate of iron,	1
Oxide of antimony,	4
Flint powder,	3

After calcining these without melting, fuse 1 part of the compound with 2½ of flux.

Dark Red.

Sulphate of iron calcined dark,	1

Flux, No. 4. 6 parts } of this 3 parts.
Colcothar 1 }

Light Red.

Red sulphate of iron,	1
Flux, No. 1.	3
White lead,	1½

Brown.

Manganese,	2¼
Red lead,	8½
Flint powder,	4

See Transactions of the Society, or the Phil. Mag. vol. 51. Mr. Tilloch justly observes, that borax should be used sparingly, as it causes efflorescence, and decay of the enamel colours.

ENDELLIONE. Bournonite.

ENTROCHI. A genus of extraneous fossils, usually of about an inch in length, and made up of a number of round joints, which, when separate and loose, are called trochitæ: they are composed of the same kind of plated spar with the fossil shells of the echini, which is usually of a bluish-grey colour, and are very bright where fresh broken: they are all striated from the centre to the circumference, and have a cavity in the middle. They seem to be the petrified arms of that singular species of the sea star-fish, called Stella arborescens.

EPIDOTE. Pistacite.—*Werner*. A subspecies of prismatoidal augite.—*Jameson*. Acanticone, from Norway. Colours, pistachio-green, and green of darker shades. Massive, in distinct granular or fibrous concretions, and crystallized. The primitive form is an oblique four-sided prism, in which the lateral planes meet at angles of 114° 37′ and 65° 23′. The secondary forms are, 1. Very oblique four-sided prisms, bevelled on the extremities. 2. That figure truncated on the acute edges, and flatly bevelled on the extremities. 3. A broad unequiangular six-sided prism, variously acuminated or truncated. 4. A very oblique four-sided prism, truncated on the obtuse lateral edges, and doubly acuminated on the extremities by four planes. The crystals are sometimes reed like, and the lateral planes are longitudinally streaked; but the truncating, acuminating, and bevelling planes are smooth, and the terminal planes diagonally streaked. Lustre splendent, internally inclining to pearly. Cleavage twofold. Fracture flat conchoidal. Translucent. Harder than felspar, but not so hard as quartz. Brittle. Sp. gr. 3.45. Before the blow-pipe it is converted into a brown-coloured scoria, which becomes black with heat. Its constituents are, silica 37, alumina 21, lime 15, oxide of iron 24, oxide of manganese, 1.5, water 1.5. Laugier found 26 alumina, 20 lime, and 13 oxide of iron. It occurs in primitive beds and veins, along with augite, garnet, hornblende, calcareous spar, copper pyrites, &c. It is found in Arran, in secondary syenite and clay-slate; in Mainland of Shetland, in syenite; in the island of Icolmkill, in a rock composed of red felspar and quartz; in the syenite of Glencoe; in similar rocks among the Malvern hills; in quartz, at Wallow Crag, near Keswick; in Cornwall; Arendal, in Norway; in Bavaria, France, &c.

EPIDERMIS. If the human skin be macerated in hot water, it separates into two parts, the *cutis*, or true skin, and the *epidermis*, or scarf skin. The continued action of warm water at length dissolves the cutis, but does not affect the epidermis, neither does alcohol. Caustic alkali, however, dissolves it. It resembles coagulated albumen.

EPSOM SALT. Sulphate of magnesia.

EQUIVALENTS (CHEMICAL). A term happily introduced into chemistry by Dr. Wollaston, to express the system of definite ratios, in which the corpuscular subjects of this science reciprocally combine, referred to a common standard, reckoned unity. If, with this profound philosopher, we assume oxygen as the standard, from its almost universal relations to chemical matter, then calling it unity, we shall have, in the following examples, these ratios reduced to their lowest terms, in which the equivalents will be PRIME ratios:—

The lowest ratio, or equivalent prime of oxygen being	1.000
That of hydrogen will be	0.125
Of fluor? . .	0.375
Of carbon . .	0.750
Of phosphorus .	4.000
Of azote . .	1.750
Of sulphur .	2.000
Of calcium .	2.500
Of sodium .	3.000
Of potassium .	5.000
Of copper . .	8.00
Of barium . .	8.75
Of lead . .	13.00, &c.

The substances in the above table, susceptible of reciprocal saturation, can combine with oxygen or with each other, not only in proportions corresponding to these numbers, but also frequently in multiple or sub-multiple proportions. We have therefore two distinct propositions on this interesting subject:

1st, The general reciprocity of the saturating proportions.

2d, The multiple and submultiple proportions of prime equivalents, in which any one body may unite with any other body, to constitute successive binary compounds.

The first proposition, or grand law of chemical combination, was discovered by J. B. Richter, of Berlin, about the year 1792. The second, of equal importance, was suggested so early as the year 1788, by Mr. W. Higgins, but was first developed and demonstrated by Mr. Dalton in his New System of Chemical Philosophy.

Richter inferred his from the remarkable and well established fact, that two neutral salts, in reciprocally decomposing each other, give birth to two new saline compounds, always perfectly neutral. Thus, sulphate of soda being added to muriate of lime, will produce perfectly neutral sulphate of lime and muriate of soda. The conclusions he drew were, 1st, That the quantities of two alkaline bases, adequate to neutralize equal weights of any one acid, are proportional to the quantities of the same bases, requisite to neutralize the same weights of every other acid. For example, 6 parts of potash, or 4 of soda, neutralise 5 of sulphuric acid; and 4.4 of potash are adequate to the saturation of 5 of nitric acid. Therefore, to find the quantity of *soda* equivalent to the saturation of this weight of nitric acid, we need not make experiments, but merely compute it by the proportional rule of Richter. Thus, as 6 : 4.4 : : 4 : 2.93; or in words, as the potash, equivalent to the sulphuric acid, is to the potash, equivalent to the nitric acid, so is the soda, equivalent to the first, to the soda, equivalent to the second. And again, if 6.5 potash saturate 5 of muriatic acid gas, how much soda, by Richter's rule, will be required for the same effect? We say 6 : 6.5 : : 4 : 4.3. 3dly, If 10.9 potash combine with 5 of carbonic acid, how much soda will be equivalent to that effect? Now, 6 : 10.9 : : 4 : 7.26. Here, therefore, we have found, that if 6 potash be equivalent to 4 soda, in saturating 5 of sulphuric acid, this ratio of 6 to 4, or 3 to 2, will pervade all the possible saline combinations; so that, whatever be the quantity of potash requisite to saturate 5, 10, &c. of any other acid, two-thirds of that quantity of soda will suffice.

In the same manner let us find out, for five of sulphuric, or of any one standard acid, the saturating quantity of ammonia, magnesia, lime, strontites, barytes, peroxide of copper, and the other bases; then their proportions to potash, thus ascertained, for this acid will, by arithmetical reduction, give their saturating quantity of every other acid, whose relation to potash, or indeed to any one of these bases, is known.

The experimental verification of this most important law, occupied Richter from the year 1791 to the year 1802, in which period he published, in successive parts, a curious work, entitled the Geometry of the Chemical Elements, or Principles of Stechiometry. We might have expected greater accuracy in his investigations, from the circumstance, that Dr. Wollaston selected *his* statement of the constituents of nitre, in preference to those of all other chemists, in the construction of his admirable table of chemical proportions.

With indefatigable zeal Richter examined, by experiment, each acid in its relation to the bases, and then compared the results with those given by calculation, presenting both in an extensive series of tables.

It is curious that he does not seem to have been aware, that all his tables might have been reduced into a single one, of 21 numbers, divided into two columns, by means of which, every question relating to the included articles might be solved by the rule of three, or a sliding scale. The following table, computed by Fischer from Richter's last tables, was inserted by the celebrated Berthollet in a note to his chemical statics.

Bases.		Oxygen = 1.	Acids.		Oxygen = 1.
Alumina,	525	2·625	Fluoric,	427	2·135
Magnesia,	615	3·075	Carbonic,	577	2·885
Ammonia,	672	3·36	Sebacic,	706	3·530
Lime,	793	3·965	Muriatic,	712	3·560
Soda,	859	4·245	Oxalic,	755	3·775
Strontian,	1329	6·645	Phosphoric,	979	4·895
Potash,	1605	8·025	Formic,	988	4·94
Barytes	2222	1·111	Sulphuric,	1000	5·000
			Succinic,	1209	6·045
			Nitric,	1405	7·025
			Acetic,	1480	7·400
			Citric,	1683	8·415
			Tartareous,	1694	8·470

I have added the two columns under oxygen, from which we see at once, that, with the exception of the bases lime, strontian, and soda, and the acids carbonic, muriatic, sulphuric, nitric, citric, and tartaric, the numbers given by Richter do not form tolerable approximations to the true proportions. The object of the above table was, to give directly the quantities of acid and alkali requisite for mutual saturation. For example, 1605, opposite to potash, is the quantity of that alkali equivalent to neutralize 427 of fluoric acid, 577 carbonic, 712 muriatic, 1000 sulphuric, &c. Each column affords also progressively increasing numbers. Those nearest the top have the greatest acid or alkaline energies, as measured by their powers of saturation. The column of Richter gives, therefore, as far as the analytical means of his time permitted, a table of the relative weights of what has since been hypothetically called *the atoms*.

But two chemical constituents frequently unite in different proportions, forming distinct and often dissimilar compounds. Thus, oxygen and azote constitute in one proportion, nitrous oxide, the intoxicating gas of Sir H. Davy; in a second proportion, nitric oxide, the nitrous gas of Priestley; in a third proportion, nitrous acid; and in a fourth proportion, nitric acid. Is there any law regulating these various compounds; so that knowing the first proportion, we may infer the whole series? This question was first considered in a work containing many curious though vague anticipations of discoveries; I mean Mr. Higgins's Comparative View of the Phlogistic and Antiphlogistic Theory, printed in 1788, and published early in 1789. Besides some additional facts, decisively hostile to the hypothesis of phlogiston, this publication indicates the doctrine of multiple proportion, with regard to the successive compounds of the same constituents. This was likewise interwoven with somewhat fantastical views concerning gaseous and atomical combination. Mr. Higgins published, in 1814, a book, entitled, Experiments and Observations on the Atomic Theory and Electrical Phenomena. In this work he gives numerous quotations from his *Comparative View*, in order to establish his claim of priority to the discovery of multiple proportions, and the atomic theory of chemistry. We have reason to be surprised at his rejection of many errors then sanctioned by high authority, and his promulgation of many new truths, which might appear, to contemporary writers, insulated, or of little consequence, but to which subsequent researches have given a due place and importance in the system of chemical knowledge. I shall quote a few passages, as he gives them, from his Comparative View.

"Hepatic gas (sulphuretted hydrogen), as shall be shown, is hydrogen in its full extent, holding sulphur in solution." This fact, of hydrogen not changing its volume by combining with sulphur, has been marked among the discoveries of later times.

"Therefore, 100 grains of sulphur require only 100 or 102 of the dry gravitating matter of oxygen gas, to form sulphurous acid. As sulphurous acid gas is very little more than double the specific gravity of oxygen gas, we may conclude, that the ultimate particles of sulphur and oxygen contain the same quantity of matter; for oxygen gas suffers no considerable diminution of its bulk, by uniting to the quantity of sulphur necessary for the formation of sulphurous acid. It contracts 1-11th, as shall be shown hereafter." Sir H. Davy has since proved, by accurate experiments, that hydrogen, in its conversion into sulphuretted hydrogen, does *not* change its bulk, agreeably to Mr. Higgins's early enunciation.

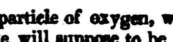
The elementary proposition of Mr. Dalton's atomical hypothesis, seems to be announced in the following paragraph of Mr. Higgins.

"As two cubic inches of hydrogen gas require but one cubic inch of oxygen gas to condense them to water, we may presume that they contain an equal number of divisions, and that the difference of the specific gravity of those gases depends on the size of their respective particles; or we may suppose, that an ultimate particle of hydrogen requires two or three or more particles of oxygen to saturate it. Were this the case, water, or its constituents, might be obtained in an intermediate state of combination, like those of sulphur and oxygen, or azote and oxygen, &c. This appears to be impossible; for in whatever proportion we mix hydrogen or oxygen gases, or under whatever circumstances we unite them, the result is invariably the same. Water is formed, and the surplus of either of the gases is left behind unchanged."—"From these circumstances we have sufficient reason to conclude, that water is composed of a single ultimate particle of oxygen, and an ultimate particle of hydrogen, and that its atoms are incapable of uniting to a third particle of either of its constituents."

Mr. Higgins inculcates very strongly, that when a body is capable of combining with another in two proportions, the third particle introduced is held by a much weaker affinity than that which unites the particles of the first or true binary compound.

"In my opinion, the most perfect nitrous acid contains 5 of oxygen and 1 of azote. Nitrous gas, according to Kirwan, contains 2 volumes of oxygen gas, and 1 of azotic gas. According to Lavoisier, 100 grains of nitrous gas contain 32 grains of azote, and 68 of oxygen. I am of the former philosopher's opinion. I also am of opinion that every primary particle of azote is united to 2 of oxygen, and that the molecule thus formed is surrounded with one common atmosphere of caloric.

"As this requires demonstration, let A in the annexed diagram represent an ultimate particle of azote, which attracts oxygen with the force of 3;



Let *a* be a particle of oxygen, whose attraction to A we will suppose to be three more; hence they will unite with the force of 6: the nature of this compound will be hereafter explained. Let us consider this to be the utmost force of attraction that can subsist between oxygen and azote. We will now suppose a second particle of oxygen *b* to combine with A; they will only unite with the force of $4\frac{1}{2}$."
"This I consider to be the real structure of a molecule of nitrous gas. Let a third particle of oxygen *c* unite to A, it will combine only with the force of 4. This is the state of the red molecules of nitrous vapour, or when con-

densed, the red nitrous acid." "We will suppose a fourth particle of oxygen *d* to combine with A; it will unite with the force of 3¾, and so on with the rest of the particles of oxygen as the diagram represents. This I consider to be the state of a molecule of the pale or straw-coloured nitrous acid.

"When a fifth particle of oxygen *e* unites, the force of union existing between the particles of the molecule is still diminished, as is represented by the diagram. The fractions show that the chemical attraction of azote for oxygen is nearly exhausted. This is the state of colourless nitrous acid; and in my opinion, no more oxygen can unite to the azote, having its whole force of attraction expended in the particles *a*, *b*, *c*, *d*, *e*. This illustrates the nature of saturation or definite proportions."

"We can readily perceive from the foregoing demonstrations, that oxygen is retained with less force in the colourless nitrous acid than in the straw-coloured; and the latter acid retains it with less force than the red nitrous acid; and nitrous gas holds it with still more force than the red nitrous acid. This accounts for the separation of oxygen gas from the colourless nitrous acid (nitric acid) when exposed to the sun, at the same time that the acid becomes coloured. Nitrous acid in any other state will afford no oxygen when exposed to the sun."

"Why the gaseous oxide should be more soluble in water than the nitrous gas is what I cannot account for, unless it be occasioned by the smaller size of its calorific atmospheres, which may admit its atoms to come within the gravitating influence of that fluid."

It is impossible to deny the praise of ingenuity to the above passages; and every one must be struck with their analogy, both as to atomical doctrines and the calorific atmospheres of gases, single and compound, with the language and views expanded at full length in Mr. Dalton's New System of Chemical Philosophy, first framed about the year 1803, and published in 1808. It appears that this philosopher, after meditating on the definite proportions in which oxygen was shown by M. Proust to exist in the two oxides of the same metal, on the successive combinations of oxygen and azote, and the proportions of various other chemical compounds, was finally led to conclude, that the uniformity which obtains in corpuscular combinations, results from the circumstance, that they consist of one atom of the one constituent, united generally with one atom of the other, or with two or three atoms. And he further inferred, that the relative weights of these ultimate atoms might be ascertained from the proportion of the two constituents in a neutral compound.

Chemistry is unquestionably under the greatest obligations to Mr. Dalton, for the pains with which he collated the various analyses of chemical bodies by different investigators; and for establishing, in opposition to the doctrine of indefinite affinity taught by Berthollet, that the different compounds of the same principles did not pass into each other by imperceptible gradations, but proceeded, *per saltum*, in successive proportions, each a multiple of the first. Mr. Dalton has thus been no mean contributor to the advancement of the science. It is difficult to say how far his figured groups of spherical atoms have been beneficial or not. They may have had some use in aiding the conception of learners, and perhaps in giving a novel and imposing air to the atomical fabric. But their arrangement, and even their existence, are altogether hypothetical, and therefore ought to have no place in physical demonstrations.

That water is a compound of an atom of oxygen and an atom of hydrogen, is assumed by Mr. Dalton as the basis of his system. But two volumes of hydrogen here combine with one of oxygen. He therefore infers, that an atom of hydrogen occupies double the bulk, in its gaseous state, of an atom of oxygen. These assumptions are obviously gratuitous. I agree with Dr. Prout in thinking that Sir H. Davy has taken a more philosophical view of this subject. Guided by the strict logic of chemistry, he places no hypothesis at the foundation of his fabric.

Experiment shows, 1st, That in equal volumes oxygen weighs 16 times more than hydrogen; and 2dly, That water is formed by the union of one volume of the former, and two volumes of the latter gas, or by weight of 8 to 1. We are not in the least authorised to infer from this, that an atom of oxygen weighs 8 times as much as an atom of hydrogen. For aught we know, water may be a compound of 2 atoms of hydrogen, and 1 of oxygen; in which case we should have the proportion of the weights of the atoms, as given by equal volumes, namely, 1 to 16. There is no good reason for fixing on one compound of hydrogen, more than on another, in the determination of the basis of the equivalent scale. If we deliberate on that combination of hydrogen in which its agency is apparently most energetic, namely, that with chlorine, we would surely never think of pitching on *two* volumes as its *unity* or least proportion of combination; for it is *one* volume of hydrogen which unites with one volume of chlorine, producing two volumes of muriatic gas. Here, therefore, we see that *one* volume of hydrogen is quite adequate to effect, in an active gaseous body of equal bulk and 36 times its weight, an entire change of properties. Should we assume in gaseous chemistry, 2 volumes of hydrogen as the combining unit, or as representing an atom; then it should never unite in 3 volumes, or an atom and a half with another gas. Ammonia, however, is a compound of 3 volumes of hydrogen with 1 of azote; and if two volumes of hydrogen to 1 of oxygen be called an atom to an atom, surely 3 volumes of hydrogen to 1 of azote should be called an atom and a half *to* an atom. Yet the Daltonian Commentator, on the second occasion, counts one volume an atom of hydrogen, and on the first, two volumes an atom.

We would steer clear of all these gratuitous assumptions and contradictions, by making a single volume of hydrogen represent its atom, or prime equivalent. "There is an advantage," says Dr. Prout, "in considering the volume of hydrogen equal to the atom, as, in this case, the specific gravities of most, or perhaps all elementary substances, (hydrogen being one), will either exactly coincide with, or be some multiple of the weights of their atoms; whereas, if we make the volume of oxygen unity, the weights of the atoms of most elementary substances, except oxygen, will be double that of their specific gravities, with respect to hydrogen. The assumption of the volume of hydrogen being equal to the atom, will also enable us to find more readily the specific gravities of bodies in their gaseous state, (either with respect to hydrogen or atmospheric air), by means of Dr. Wollaston's logometric scale.

"If the views we have ventured to advance be correct, we may almost consider the πρωτη ὑλη of the ancients to be realized in hydrogen: an opinion, by the by, not altogether new. If we actually consider this to be the case, and further consider the specific gravities of bodies, in their gaseous state, to represent the number of volumes condensed into one; or in other words, the number of the absolute weight of a single volume of the first matter (πρωτη ὑλη) which they contain, which is extremely probable; multiples in weight must always indicate multiples in volume, and *vice versa*; and the specific gravities or absolute weights of all bodies in a gaseous state, must be multiples of the specific gravity, or absolute weight, of the first matter, (πρωτη ὑλη), because all bodies in a gaseous state, which unite with one another, unite with reference to their volume."

From these ingenious observations, we perceive the felicity of judgment with which Sir H. Davy made choice of the single volume of hydrogen, for the unit of primary combination, in his Elements of Chemical Philosophy.

Mr. Dalton's prelections on the atomic theory, and even the first volume of his New System of Chemical Philosophy, excited no sensation in the chemical world adequate to their merits. That part of his system which treated on caloric was blended with so much mere hypothesis, that chemists transferred a portion of the scepticism thus created to his collation of primary and multiple combinations. It was Dr. Wollaston who first decided public opinion in favour of the doctrine of multiple proportions, by his elegant paper on super-acid and sub-acid salts, inserted in the Philosophical Transactions for 1808. The object of the atomic theory has been no where so happily stated as by this philosopher, in the following sentence:—

"But, since the publication of Mr. Dalton's theory of chemical combination, as explained and illustrated by Dr. Thomson, (System, 3d edit.) the inquiry which I had designed appears superfluous, as all the facts I had observed are but particular instances of the more general observation of Mr. Dalton, that in all cases the simple elements of bodies are disposed to unite atom to atom singly, or if either is in excess, it exceeds by a ratio to be expressed by some simple multiple of the number of its atoms."

It is evident from this passage, that the principle which presented itself to Mr. Dalton, on a review of the labours of *other* chemists, had really occurred to Dr. Wollaston from his *own*, and that he would unquestionably have been speedily led to its full development.

Dr. Wollaston, in the above decisive paper, demonstrates, that in the sub-carbonate and crystallized carbonate of potash, the relation of the carbonic acid to the base, in the first, is exactly one-half of what it is in the second. The same law is shown to hold with regard to the two carbonates of soda, and the two sulphates of potash; and being applied to his experiments on the compounds of potash and oxalic acid, leads him to conclude that the neutral oxalate may be considered as consisting of 2 particles of potash to 1 acid; the binoxolate as 1 and 1, or 2 potash with 2 acid; the quadroxalate as 1 and 2, or 2 potash with 4 acid.

We cannot withhold from our readers the following masterly observations, which must make every one regret that the full development of the atomic theory had not fallen within the scope of his researches.

"But an explanation which admits a double share of potash in the neutral salts (the oxalates), is not altogether satisfactory; and I am farther inclined to think that, when our views are sufficiently extended to enable us to reason with precision concerning the proportions of elementary atoms, we shall find the arithmetical relation alone will not be sufficient to explain their mutual action, and that we shall be obliged to acquire a geometrical conception of their relative arrangement, in all the three dimensions of solid extension.

"For instance, suppose the limit to the approach of particles to be the same in all directions, and hence their virtual extent to be spherical (which is the most simple hypothesis); in this case, when different sorts combine singly, there is but one mode of union. If they unite in the proportion of two to one, the two particles will naturally arrange themselves at opposite poles of that to which they unite. If they be three, they might be arranged with regularity at the angles of an equilateral triangle, in a great circle surrounding the single spherule; but in this arrangement, for want of similar matter at the poles of this circle, the equilibrium would be unstable, and would be liable to be deranged by the slightest force of adjacent combinations; but when the number of one set of particles exceeds in the proportion of 4 to 1, then, on the contrary, a stable equilibrium may again take place, if the four particles are situated at the angles of the four equilateral triangles composing a regular tetrahedron.

"But as this geometrical arrangement of the primary elements of matter is altogether conjectural, and must rely for its confirmation or rejection upon future inquiry, I am desirous that it should not be confounded with the results of the facts and observations related above, which are sufficiently distinct and satisfactory with respect to the existence of the law of simple multiples. It is perhaps too much to hope, that the geometrical arrangement of primary particles will ever be perfectly known; since, even admitting that a very small number of these atoms combining together, would have a tendency to arrange themselves in the manner I have imagined; yet, until it is ascertained how small a proportion the primary particles themselves bear to the interval between them, it may be supposed that surrounding combinations, although themselves analogous, might disturb this arrangement; and in that case, the effect of such interference must also be taken into the account, before any theory of chemical combination can be rendered complete."

I am not aware that any chemist has adduced experimental evidence, to prove that a "stable equilibrium may again take place, if the four particles are situated at the angles of the four equilateral triangles composing a regular tetrahedron." I have, therefore, much pleasure in referring to my researches on the constitution of liquid nitric acid, as unfolding a striking confirmation of Dr. Wollaston's true philosophy of atomical combination. When I wrote the following sentence, I had no recollection whatever of Dr. Wollaston's profound speculations on tetrahedral arrangement.—"We perceive, that the liquid acid of 1.420, composed of 4 primes of water + 1 of dry acid, possesses the greatest power of resisting the influence of temperature to change its state. It requires the *maximum* heat to boil it, when it distils unchanged; and the maximum cold to effect its congelation." See ACID (NITRIC), in this Dictionary.

Here we have a fine example of the stability of equilibrium, introduced by the combination of four atoms with one. The discovery which I had also the good fortune to make with regard to the constitution of aqueous sulphuric acid, that the maximum condensation occurred when one atom of the real acid was combined with three atoms of water, is equally consonant to Dr. Wollaston's views. "But in this arrangement," says Dr. Wollaston, "for want of similar matter at the poles of this circle, the equilibrium would be unstable and would be liable to be deranged by the slightest force of adjacent combinations." Compare with this remark, the following sentence from my paper on sulphuric acid, as published in the Journal of Science, Oct. 1817.—"The terms of dilution are, like logarithms, a series of numbers in arithmetical progression, corresponding to another series, namely, the specific gravities, in geometrical progression. For a little distance on both sides of the point of greatest condensation, the series converges with accelerated velocity, whence the 10 or 12 terms on either hand deviate a little from experiment." Page 126. Or in other words, a small addition of water or of acid to the above atomic group, produces a *great* change on the degree of condensation; which accords with the position "that the equilibrium would be liable to be deranged by the slightest force of adjacent combinations."

While considering this part of Dr. Wollaston's important paper, let me advert to the curious facts pointed out in the article NITRIC ACID, relative to the compound of one atom of dry acid and seven atoms water. In my paper on the subject, published in the eighth number of the Journal of Science, I showed that this liquid combination was accompanied with the greatest condensation of volume, and the greatest disengagement of heat. In composing this Dictionary, I calculated, for the first time, the atomical constitution of the nitric acids employed by Mr. Cavendish for congelation; and found with great satisfaction, that the same proportion which had exhibited, in my experiments, the most intense reciprocal action, as was indicated both by the aggregation of particles and production of heat, was likewise that which most favoured solidification. Such acid congeals at —2°; but when either stronger or weaker, it requires a much lower temperature for that effect.

3. The next capital discovery in multiple proportions was made by M. Gay Lussac, in 1808, and published by him in the second volume of the *Memoires d'Arcueil*. After detailing a series of fine experiments, he deduces the following important inferences:—"Thus it evidently appears, that all gases, in their mutual action, uniformly combine in the most simple proportions; and we have seen, in fact, in all the preceding examples, that the ratio of their union is that of 1 to 1, of 1 to 2, or of 1 to 3, by volume. It is important to observe, that when we consider the weights, there is no simple and definite relation between the elements of a first combination; it is only when there is a second between these

same elements, that the new proportion of that body which has been added is a multiple of the first. Gases, on the contrary, in such proportions as can combine, give rise always to compounds, whose elements are in volume, multiples the one of the other.

"Not only do the gases combine in very simple proportions, as we have just seen, but moreover, the apparent contraction of volume which they experience by combination, has likewise a simple relation with the volume of the gases, or rather with the volume of one of them."

By supposing the contraction of volume of the two gaseous constituents of water to be only equal to the whole volume of oxygen added, he found the ratio of the density of steam to be to that of air as 10 to 16; a computed result in exact correspondence with the experimental result lately obtained in an independent method by the same excellent philosopher. "Ammoniacal gas is composed in volume," says he, "of 3 parts of hydrogen and 1 of azote, and its density, compared to that of air, is 0.596; but if we suppose the apparent contraction to be one-half of the total volume, we find 0.594 for its density. Thus it is demonstrated by this nearly perfect accordance, that the apparent contraction of its elements is precisely one-half of the total volume, or rather double the volume of azote." M. Gay Lussac subjoins to his beautiful memoir a table of gaseous combination, which, with some modifications derived from subsequent researches, will be inserted under the article GAS.

The same volume of the *Memoires* presents another important discovery of M. Gay Lussac, on the subject of equivalent proportions. It is entitled, On the relation which exists between the oxidation of metals, and their capacity of saturation for the acids. He here proves, by a series of experiments, that the quantity of acid which the different metallic oxides require for saturation, is in the direct ratio of the quantity of oxygen which they respectively contain. "I have arrived at this principle," says he, "not by the comparison of the known proportions of the metallic salts, which are in general too inexact to enable us to recognize this law, but by observing the mutual precipitation of the metals from their solutions in acids."

When we precipitate a solution of acetate of lead by a plate of zinc, there is formed a beautiful vegetation known under the name of the *tree of Saturn*; and which arises from the reduction of the lead by a galvanic process, as was first shown by Silvester and Grotthus. We obtain at the same time a solution of acetate of zinc, equally neutral with that of the lead, and entirely exempt from this last metal. No hydrogen, or almost none, is disengaged during the precipitation; which proves, that the whole oxygen necessary to the zinc, for its becoming dissolved and saturating the acid, has been furnished to it by the lead.

If we put into a solution of sulphate of copper, slightly acidulous, bright iron turnings in excess, the copper is almost instantly precipitated; the temperature rises, and no gas is disengaged. The sulphate of iron which we obtain, is that in which the oxide is at a minimum, and its acidity is exactly the same as that of the sulphate of copper employed.

We obtain similar results by decomposing the acetate of copper by lead, especially with the aid of heat. But since the zinc precipitates the lead from its acetic solution, we may conclude, that it would also precipitate copper from its combination with the acetic acid. Experience is here in perfect accordance with theory.

We know with what facility copper precipitates silver from its nitric solution. All the oxygen which it needs for its solution is furnished to it by the oxide of silver; for no gas is disengaged, and the acidity is unchanged. The same thing happens with copper in regard to nitrate of mercury, and to cobalt in regard to nitrate of silver. In these last examples, as in the preceding, the precipitating metal finds, in the oxide of the metal which it precipitates, all the oxygen which is necessary to it for its oxidizement, and for neutralizing to the same degree the acid of the solution.

These incontestable facts naturally conduct to the principle announced above, that the acid in the metallic salts is directly proportional to the oxygen in their oxides. In the precipitation of one metal by another, the quantity of oxygen in each oxide remains the same, and consequently the larger dose of oxygen the precipitating metal takes, the less metal will it precipitate.

M. Gay Lussac next proceeds to show, with regard to the same metals at their different stages of oxidizement, that they require of acid a quantity precisely proportional to the quantity of oxygen they may contain; or that the acid in the salts is exactly proportional to the oxygen of the oxides. A very important result of this law is, the ready means it affords of determining the proportions of all the metallic salts. The proportions of one metallic salt, and the oxidation of the metals being given, we may determine those of all the salts of the same genus; or the proportions of acid, and of oxide, of all the metallic salts, and the oxidation of a single metal being given, we can calculate the oxidation of all the rest. Since the peroxides require most acid, we can easily understand how the salts containing them should be in general more soluble than those with the protoxide.

M. Gay Lussac concludes his memoir with this observation. When we precipitate a metallic solution, by sulphuretted hydrogen, either alone or combined with an alkaline base, we obtain a sulphuret or a metallic hydrosulphuret. In the first case, the hydrogen of the sulphuretted hydrogen combines with all the oxygen of the oxide, and the sulphur forms a sulphuret with the metal: in the second case, the sulphuretted hydrogen combines directly with the oxide, without being decomposed; and its proportion is such that there is sufficient hydrogen to saturate all the oxygen of the oxide. The quantity of hydrogen neutralized, or capable of being so, depends therefore on the oxidation of the metal, as well as the quantity of the sulphur which can combine with it. Of consequence, the same metal forms as many distinct sulphurets, as it is susceptible of distinct stages of oxidation in its acid solutions. And as these degrees of oxidation are fixed, we may also obtain sulphurets, of definite proportions, which we can easily determine, according to the quantity of oxygen to each metal, and the proportions of sulphuretted hydrogen.

The next chemist who contributed essentially to the improvement of the equivalent ratios of chemical bodies, was Berzelius. By an astonishing number of analyses, executed for the most part with remarkable precision, he enabled chemical philosophers to fix, with corresponding accuracy, the equivalent ratios reduced to their lowest terms. He himself took oxygen as the unit of proportion.

The results of all this emulous cultivation were combined, and illustrated with original researches, by Sir H. Davy, in his Elements of Chemical Philosophy, published in 1812.

What peculiarly characterizes this chemical work, is the sound antihypothetical doctrines which it inculcates on chemical combination. "Mr. Higgins," says Sir H. "has supposed that water is composed of one particle of oxygen and one of hydrogen, and Mr. Dalton of an atom of each; but in the doctrine of proportions derived from facts, it is not necessary to consider the combining bodies, either as composed of indivisible particles, or even as always united, one and one, or one and two, or one and three proportions. Cases will be hereafter pointed out, in which the ratios are very different; and at present, as we have no means whatever of judging either of the relative numbers, figures, or weights, of those particles of bodies which are not in contact, our numerical expressions ought to relate only to the results of experiments."

He conceives that the calculations will be much expedited, and the formulæ rendered more simple, by considering the smallest proportion of any combining body, namely, that of hydrogen, as the integer. This radical proportion of hydrogen, is the πρωτη ὕλη of the ancient philosophers.

It has been objected by some, to our assuming hydrogen as the unit, that the numbers representing the metals would become inconveniently large. But this could never be urged by any person acquainted with the theory of numbers. For in what respect is it more convenient to reckon barium 8·75 on the atomic scale, or 8.75 × 16 = 140 on Sir H. Davy's scale of experiment; or is it any advantage to name, with Dr. Thomson, tin = 7.375, or to call it 118, on the plan of the English philosopher? If the combining ratios of all bodies be multiples of hydrogen, as is probable, why not take hydrogen as the unit? I think this question will not be answered in the negative, by those who practise the reduction of chemical proportions. The defenders of the Daltonian hypothesis, that water consists of one atom oxygen to one atom hydrogen, may refer to Dr. Wollaston's scale, as authority for taking oxygen as the unit. But that admirable instrument, which has at once subjected thousands of chemical combinations to all the dispatch and precision of logometric calculation, is actually better adapted to the hydrogen unit than to the oxygen. For if we slide down the middle rule, till 10 on *it* stand opposite to 10 hydrogen on the left side, every thing on the scale is given in accordance with Sir H. Davy's system of primary proportions, and M. Gay Lussac's theory of gaseous combination. This valuable concurrence, as is well pointed out by Dr. Prout, we lose, by adopting the volume of oxygen as *radix*.

In the first part of the Phil. Trans. for 1814, appeared Dr. Wollaston's description of his scale of chemical equivalents,—an instrument which has contributed more to facilitate the general study and practice of chemistry than any other invention of man. His paper is further valuable, in presenting a series of numbers denoting the relative primary proportions, or weights of the atoms of the principal chemical bodies, both simple and compound, determined with singular sagacity, from a general review of the most exact analyses of other chemists, as well as his own.

The list of substances which he has estimated, are arranged on one or other side of a scale of numbers, in the order of their relative weights, and at such distances from each other, according to their weights, that the series of numbers placed on a sliding scale can at pleasure be moved, so that any number expressing the weight of a compound, may be brought to correspond with the place of that compound in the adjacent column. The arrangement is then such, that the weight of any ingredient in its composition, of any reagent to be employed, or precipitate that might be obtained in its analysis, will be found opposite the point at which its respective name is placed.

If the slider be drawn upwards, till 100 corresponds to muriate of soda, the scale will then show how much of each substance contained in the table is equivalent to 100 of common salt. It shows, with regard to the different views of this salt, that it contains 46.6 dry muriatic acid, and 53.4 of soda, or

39.8 sodium, and 13.6 oxygen; or if viewed as chloride of sodium, that it contains 60.2 chlorine, and 39.8 sodium. With respect to reagents, it may be seen, that 283 nitrate of lead, containing 191 of litharge, employed to separate the muriatic acid, would yield a precipitate of 237 muriate of lead, and that there would then remain in solution nearly 146 nitrate of soda. It may at the same time be seen, that the acid in this quantity of salt would serve to make 232 corrosive sublimate, containing 185.5 red oxide of mercury; or make 91.5 muriate of ammonia, composed of 62 muriatic gas (or hydromuriatic acid), and 29.5 ammonia. The scale shows also, that for the purpose of obtaining the whole of the acid in distillation, the quantity of oil of vitriol required is nearly 84, and that the residuum of this distillation would be 122 dry sulphate of soda, from which might be obtained, by crystallization, 277 of Glauber salt, containing 155 water of crystallization. These, and many more such answers, appear at once, by bare inspection, as soon as the weight of any substance intended for examination is made, by motion of the slider, correctly to correspond with its place in the adjacent column. Now, surely, the accurate and immediate solution of so many important practical problems, is an incalculable benefit conferred on the chemist.

With regard to the method of laying down the divisions of this scale, those who are accustomed to the use of other sliding rules, and are practically acquainted with their properties, will recognize upon the slider itself, the common Gunter's line of numbers (as it is called), and will be satisfied, that the results which it gives are the same that would be obtained by arithmetical computation.

Those who are acquainted with the doctrine of ratios, and with the use of logarithms as measures of ratios, will understand the principle on which this scale is founded, and will not need to be told, that all the divisions are logometric; consequently, that the mechanical addition and subtraction of ratios here performed by juxtaposition, correspond in effect to the multiplication and division of the numbers, by which those ratios are expressed in common arithmetical notation.

In his Essay on the Cause of Chemical Proportions, Berzelius proposed a system of signs, to denote atomical combinations, which it may be proper briefly to explain. This sign is the initial letter, and by itself always expresses one atom, volume, or prime of the substance. When it is necessary to indicate several volumes or primes, it is done by prefixing the number; for example, the cuprous oxide, or protoxide of copper, is composed of a prime of oxygen and a prime of metal; its sign is therefore $Cu + O$. The cupric oxide, or deutoxide of copper, is composed of 1 prime metal, and 2 primes oxygen; therefore its sign is $Cu + 2\ O$. In like manner the sign for sulphuric acid is $S + 3\ O$; for carbonic acid, $C + 2\ O$; for water, $2\ H + O$, &c.

When we express a compound prime of the first order, or binary, we throw away the +, and place the number of primes above the letter, as the index or exponent is placed in arithmetic. For example, $Cu\,O + SO^3$ = sulphate of copper; $CuO^2 + 2SO^3$ = bideutosulphate of copper, or persulphate. These formulæ have this advantage, that if we take away the oxygen, we see at once the ratio between the radicals. As to the primes of the second order, or ternary compounds, it is but rarely of any advantage to express them by formulæ, as one prime; but if we wish to express them in that way, we may do it by using the parenthesis, as is done in algebraic formulæ: for example, according to Berzelius, alum is composed of 3 primes of sulphate of alumina, and 1 of sulphate of potash. Its symbol is $3\ (Al\ O^2 + 2SO^3) + (Po^2 + 2SO^3)$. The prime of ammonia is $3HN$; viz. 3 primes hydrogen + 1 nitrogen. We shall use some of these abbreviations in our table of equivalent primes, at the article SALT.

To reduce analytical results, as usually given for 100 parts, to the equivalent prime ratios, or, in hypothetical language, to the atomic proportions, is now a problem of perpetual recurrence, with which students are perplexed, as no rule has been given for its ready solution. Though numerous examples of its solution occur in this Dictionary, we shall here explain it in detail.

As in all reasoning we must proceed from what is known or determinate, to what is unknown or indeterminate, so, in every analysis, there must be one ingredient whose prime equivalent is well ascertained. This is employed as the common measure, and the proportions of the rest are compared to it. Let us take, for instance, Sir H. Davy's analysis of fluate of lime, to determine the unknown number that should denote the prime of fluoric acid. We know, first of all, that two primes of oxygen = 2, combine with 1 of carbon = 0.75, to form the compound prime 2.75 of carbonic acid. We likewise know that carbonate of lime consists of 44 carbonic acid + 56 lime. We therefore make this proportion to determine the prime equivalent of lime.

1. 44 : 56 : : 2.75 : 3.5 = prime of lime.

2. We know that 100 parts of dry sulphate of lime, consist of 41.2 lime and 58.8 acid. Hence, to find the prime of sulphuric acid, we make this proportion:

41.2 : 58.8 : : 3.5 : 5 = prime of sulphuric acid.

3. Sir H. Davy obtained from 100 grains of fluor spar in powder, acted on with repeated quantities of sulphuric acid, and ignited, 175.2 grains of sulphate of lime. Now, since

100 grains of sulphate of lime contain, as above, 41.2 of lime, we have this proportion:

100 : 41.2 : : 175.2 : 72.18 = lime, corresponding to 175.2 grains of sulphate, and which previously existed in the 100 gr. of fluor spar. If from 100 we subtract 72.18, the difference 27.82 is the fluoric acid, or the other ingredient of the fluor, which saturated the lime. Now to find its prime equivalent, we say,

72.18 : 3.560 : : 27.82 : 1.349 = the prime or atom of fluoric acid from Sir H. Davy's experiment; or in round numbers = 1.35.

We shall give another example, derived from a more complex subject.

M. Vauquelin found, that 33 parts of lime, saturated with sorbic acid, and carefully dried, weighed 100 grains. Hence the difference, 67 grains, was acid. To find its equivalent prime, we say,

As 33 : 67 : : 3.5 = the prime of lime : 7.1 = the prime of the acid. But as he brought it to absolute neutrality by a small portion of potash, we may take 7.5 for the prime.

M. Vauquelin subjected the acid, as it exists in the dry sorbates of lead and copper, to igneous analysis; and obtained the following results:

Hydrogen,	16.8
Carbon,	28.3
Oxygen,	54.9
	100.0

Now we must find such an assemblage of the primes or atoms of these elements, as will form a sum-total of 7.5; and at the same time be to each other in the above proportions. The following very simple rule will give a ready approximation; and with a common sliding scale it may be worked by inspection.

Multiply each proportion per cent. by the compound prime, and compare the products with the multiples of the constituent primes. You can then estimate the number of each prime requisite to compose the whole. Thus,

			Theory.	Experiment.
0.168 × 7.5 = 1.2600	or 10 hydrogen	= 1.25	16.7	16.8
0.283 × 7.5 = 2.1225	3 carbon	= 2.25	30.0	28.3
0.549 × 7.5 = 4.1175	4 oxygen	= 4.00	53.3	54.9
		7.50	100.0	100.0

The differences between these theoretical and experimental proportions, are probably within the limits of the errors of the latter, in the present state of analysis.

If, on Dr. Wollaston's scale, we mark with a type or a pen, 2h, 3h, &c. up to 10h; 2c, 3c, 4c, 5c; and 2n, 3n, 4n; respectively opposite to twice, thrice, &c. the atoms of hydrogen, carbon, and nitrogen, as is already done for oxygen, (with the exception of the fourth, where copper stands), we shall then have ready approximations to the prime components, by inspection of the scale. Move the sliding part, so that one of the quantities per cent. may stand opposite the nearest estimate of a multiple prime of that constituent. Thus we know that hydrogen, carbon, and oxygen, bear the relation to each other of 1, 6, 8; and, of course, the latter two, that of 3 to 4. But 54.9 oxygen, being more than one-half of 100, the weight of oxygen in the compound prime is more than the half of 7.5, and therefore points to 4. Place 54.9 opposite 4 oxygen, (where copper stands), we shall find 18 opposite 10 hydrogen, and 30.7 opposite 3 carbon. Here we see the proportions of carbon and hydrogen are both greater than by Vauquelin's analysis. Try 51 opposite 4 oxygen, then opposite 3 carbon we have 28.7, and opposite 10 hydrogen 16.9. The proportions I have calculated arithmetically above, seem somewhat better approximations; they were deduced from hydrogen 0.125, and carbon 0.75, instead of 0.132 and 0.754, as on the scale.

If the weight of the compound prime is not given, then we must proceed to estimate the nearest prime proportions, after inspection of those per cent. The scale may be used with advantage, as just now explained.

The following case has been reckoned difficult of solution, and has been even involved in an algebraic formula. Let us suppose a vegetable acid, containing combined water, whose prime equivalent is to be determined by experiment. A crystallized salt is made with *it*, for example, and a determinate quantity of soda. Suppose the alkali to form 26 per cent. of the salt. The rest is water and acid. Dissolve 100 grains, and add them to an indefinite quantity of the solution of any salt, with whose base the vegetable acid forms an insoluble compound. Dry and weigh this precipitate. Without decomposing the latter, we have sufficient data for determining the prime equivalent of the real acid. We make this proportion: As the weight of soda is to *its* prime equivalent, so is the weight of the precipitate to the prime of the compound. Suppose 148 grains of an insoluble salt of lead to have been obtained; then 26 : 3.95 : : 148 : 22.1 = the prime of the salt of lead. From this, if we deduct the weight of the prime equivalent of oxide of lead = 14, we have 8.1 for the prime equivalent of the acid.

And the crystallized salt must have consisted of,

Dry acid,	53.3
Soda,	26.0
Water,	20.7
	100.0

As the above numbers were assumed merely for arithmetical illustration, the water is not atomically expressed. Indeed the problem of finding the acid prime, does not require the salt to be either dried or weighed. A solution would suffice. Saturate a known weight of alkali with an unknown quantity of the crystallized acid. Add this neutral solution to a redundant quantity of solution of nitrate of lead. Wash, dry, and weigh the insoluble precipitate, and apply the above rule.

There are three systems of equivalent numbers at present employed: 1st, That having oxygen as the radix; 2d, That having one volume of hydrogen as the radix; 3d, That having two volumes of hydrogen as the radix, on the Daltonian supposition, that two volumes of hydrogen contain the same number of atoms as one volume of oxygen. Since the volume of hydrogen is equal in weight to 1-16th the weight of the volume of oxygen, the former two systems are mutually convertible, by multiplying the number in the oxygen ratio by 16, or 4 × 4, to obtain the number in the hydrogen scale; and this is reconverted by the inverse operation, namely, dividing by 16, or by 4 × 4.

Dr. Wollaston's scale, and Sir H. Davy's proportional numbers, are adapted to the idea that water is a compound of 1 hydrogen + 7.5 oxygen by weight, or 15 + 1 by volume. Their mutual conversion is therefore very easy; for if we add to Dr. Wollaston's number its half, the sum is Sir H. Davy's; and of course, if we subtract from the number of the latter its third, the remainder is Dr. Wollaston's number. There is one very frequent variation in the weights of the primes among the best writers, namely, doubling or halving the number. This difference is occasioned generally by an uncertainty about the first term or proportion in which the body combines with oxygen; some chemists reckoning that a protoxide which others consider a deutoxide. Thus Sir H. Davy gives 103 as the number representing iron; from which, if we deduct $\frac{103}{3}$ = 34.3, the remainder 68.7 is nearly double of 34.5, the number of Dr. Wollaston.

I shall insert here a table of prime equivalents. The first column of numbers corresponds, in general, to the determinations of the chemists of this country, hydrogen being reckoned unity; the second column of numbers, as also the literal symbols, belong to Berzelius, who takes for his radix, oxygen = 100.—*Annals of Phil. N. S.* vii. 185, and ix. 439.

TABLE OF CHEMICAL EQUIVALENTS.

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Acid, acetic	50	641·12	$\overline{A}$
— crystallized (1 water) . .	59		
— arsenic	62	1440·77	$\overset{:\cdot:}{As}$
— arsenious	54	1240·77	$\dddot{As}$
— benzoic	120	1509·55	$\overline{B}$
— boracic ?	22	269·65	$\ddot{B}$
—— crystallized (2 water) . .	40		
— carbonic	22	275·33	$\ddot{C}$
— chloric	76	942·65	$\overset{:::::}{M}$
— chloriodic	161		
— chlorocarbonic . . .	58		
— chlorocyanic	62		
— chromic	52	1303·64	$\overset{:::}{Ch}$
— citric	58	727·85	$\overline{C}$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Acid, citric, crystallized (2 water) .	76		
— columbic ?	152	1923·15	$\dot{Ta}$
— ferrocyanic	?		
— fluoboric ?	22	544·68	$\ddot{F}\,\ddot{B}$
— fluoric	17	275·03	$\ddot{F}$
— formic	37	463·93	$\overline{F}$
— fluosilicic	24	2017·93	$\ddot{F}^3\,\dddot{Si}^2$
— gallic ?	63	791·78	$\overline{G}$
— hydriodic	126		
— hydrocyanic	27		
— hydrofluoric	17		
— hydrosulphurous . . .	24		
— hyposulphuric	36		
— iodic	165	2066·70	$\overset{\cdot\cdot\cdot\cdot\cdot}{I}$
— malic	70		
— molybdic	72	896·80	$\dddot{Mo}$
— molybdous	64	796·80	$\ddot{Mo}$
— muriatic	37	342·65	$\ddot{M}$
— nitric (dry)	54	677·26	$\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
—— liquid, sp. gr. 1.485, (2 water)	72		
— nitrous	46	477·26	$\ddddot{N}$
— oxalic	36	2710·6	$\overline{O}$
—— crystallized (4 water) . .	72		
— perchloric	92	1142·65	$\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{M}$
— phosphoric	28	892·30	$\overset{\cdot\cdot\cdot\cdot\cdot}{P}$
— phosphorous	20	692·30	$\dddot{P}$
— saclactic	105		
— succinic (anhydrous crystals) .	50	627·85	$\overline{S}$
— sulphuric (dry)	40	501·16	$\dddot{S}$
—— liquid, sp. gr. 1.4838 . .	49		
— sulphurous	32	401·16	$\ddot{S}$
— tartaric	67	834·49	$\overline{T}$
—— crystallized (1 water) . .	76		
— tungstic	120	1507·69	$\dddot{W}$
— uric	45 ?		
Alum (dry)	262		
— crystallized (25 water) . .	487		

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Alumina	27	642·33	$\dddot{Al}$
— sulphate	67	2145·80	$\dddot{Al}\,\dddot{S}^3$
— subsulphate (2 acid 3 base)	116		
Aluminum	19	342·33	Al
Ammonia	17	214·67	$\dot{N}H^6$
— acetate	67	856·56	$\dot{N}H^6\overline{A}$
— bicarbonate (2 water)	79	766·10	$\dot{N}H^6\ddot{C}^2$
— borate ? (dry)	39	485·09	$\dot{N}H^6\ddot{B}$
— crystallized (2 water)	57		
— carbonate	39	490·77	$\dot{N}H^6\ddot{C}$
— sesquicarbonate (2 water)	118		
— citrate	75	943·33	$\dot{N}H^6\overline{C}$
— fluoborate	39		
— hydriodate	143		
— iodate	182	2282·14	$\dot{N}H^6\overset{\cdot\cdot\cdot\cdot\cdot}{I}$
— molybdate	89	1112·24	$\dot{N}H^6\dddot{Mo}$
— muriate	54	558·09	$\dot{N}H^6\ddot{M}$
— nitrate	71	891·83	$\dot{N}H^6\overset{\cdot\cdot\cdot\cdot\cdot}{N}$
— oxalate	53	667·21	$\dot{N}H^6\overline{O}$
— (crystallized, 1 water)	62		
— phosphate	45	1321·44	$2\,\dot{N}H^6+\overset{\cdot\cdot\cdot\cdot\cdot}{P}$
— phosphite	37	1121·44	$2\,\dot{N}H^6+\dddot{P}$
— succinate	67	842·42	$\dot{N}H^6\overline{S}$
— sulphate	57	715·73	$\dot{N}H^6\dddot{S}$
— sulphite	49	615·73	$\dot{N}H^6\ddot{S}$
— tartrate	84	1049·06	$\dot{N}H^6\overline{T}$
— potassa-tartrate	208		
Antimony	44	1612·90	Sb
— chloride	80	2940·85	$\dddot{Sb}\,\ddot{M}^3$
— iodide	169	6313·0	$\dddot{Sb}\,\ddot{I}^3$
— deutoxide	56	2012·90	$\ddddot{Sb}$
— peroxide	60	2112·90	$\overset{\cdot\cdot\cdot\cdot\cdot}{Sb}$
— protoxide	52	1912·90	$\dddot{Sb}$
— sulphuret	60	2216·38	$Sb\,S^3$
— potassa-tartrate	?		
Arseniate of ammonia	79	1871·65	$2\,\dot{N}H^6\overset{\cdot\cdot\cdot\cdot\cdot}{As}$
— potash	110	2620·60	$\ddot{K}\,\overset{\cdot\cdot\cdot\cdot\cdot}{As}$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Arseniate of soda	94	2222·61	$\ddot{Na}\,\overset{:\cdot:}{As}$
Arsenic	38	940·77	As
— acid	62		
— chloride	?		
— iodide	?		
Arsenious acid	54		
Azote	14	177·26	$\dot{N}$
Barium	70	1713·86	Ba
— chloride	106	2599·16	$\ddot{Ba}\,\ddot{M}^2$
— iodide	195	4847·26	$\ddot{Ba}\,\ddot{I}^2$
— peroxide	86	2013·86	$\dddot{Ba}$?
— phosphuret	82	2106·16	Ba P ?
— sulphuret	86		
Barytes	78	1913·86	$\ddot{Ba}$
— acetate	128	3196·1	$\ddot{Ba}\,\overline{A}^2$
— arseniate	140	3354·63	$\ddot{Ba}\,\overset{:\cdot:}{As}$
— arsenite	132	4395·40	$\ddot{Ba}\,\dddot{As}^2$
— benzoate	198	4932·96	$\ddot{Ba}\,\overline{B}^2$
— borate	100	2453·17	$\dot{Ba}\,\ddot{B}^2$
— carbonate	100	2464·52	$\ddot{Ba}\,\ddot{C}^2$
— chlorate	154	3799·16	$\ddot{Ba}\,\overset{::\,::}{M}^2$
— chromate	130	3217·50	$\ddot{Ba}\,\overset{:::}{Ch}$
— citrate	136	3369·56	$\ddot{Ba}\,\overline{C}^2$
— hydrate	87	2138·73	$\ddot{Ba} + 2Aq$
— iodate	243	6047·26	$\ddot{Ba}\,\overset{::\,::}{I}^2$
— nitrate	132	3268·38	$\ddot{Ba}\,\overset{:::}{N}^2$
— muriate (crystallized, 1 water)	124	3048·90	$\ddot{Ba}\,\ddot{M}^2 + 4Aq$
— oxalate	114	2817·40	$\ddot{Ba}\,\overline{O}^2$
— phosphate	106	2806·16	$\ddot{Ba}\,\overset{:\cdot:}{P}$
— phosphite	98	2606·16	$\ddot{Ba}\,\dddot{P}$
— succinate	128	3169·56	$\ddot{Ba}\,\overline{S}^2$
— sulphate	118	2916·18	$\ddot{Ba}\,\dddot{S}^2$
— sulphite	110	2716·18	$\ddot{Ba}\,\ddot{S}^2$
— tartrate	145	3582·84	$\ddot{Ba}\,\overline{T}^2$
— tungstate	198	4929·24	$\ddot{Ba}\,\dddot{W}^2$
Benzoic acid	120	1509·55	$\overline{B}$
Bicarburetted hydrogen	7	88·60	$H^2\,C$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Bismuth	72	1773·8	Bi
— acetate	130	3256·0	$\ddot{Bi}\,\overline{A}^2$
— arseniate	142	3414·57	$\ddot{Bi}\,\overset{:\cdot:}{As}$
— benzoate	200	4992·90	$\ddot{Bi}\,\overline{B}^2$
— chloride	108	2659·10	$\ddot{Bi}\,\ddot{M}^2$
— citrate	138	3429·5	$\ddot{Bi}\,\overline{C}^2$
— iodate	245	6107·2	$\ddot{Bi}\,\overset{:\cdot:}{I}^2$
— iodide	197	4907·2	$\ddot{Bi}\,\ddot{I}^2$
— nitrate	134	3328·32	$\ddot{Bi}\,\overset{:\cdot:}{N}^2$
— oxalate	116	2877·34	$\ddot{Bi}\,\overline{O}^2$
— oxide	80	1973·80	$\ddot{Bi}$
— phosphate	107	2866·10	$\ddot{Bi}\,\overset{:\cdot:}{P}^2$
— phosphuret	84		
— sulphate	120	2976·12	$\ddot{Bi}\,\dddot{S}^2$
— sulphuret	88	2176·12	$Bi\,S^2$
— tartrate	147	3642·78	$\ddot{Bi}\,\overline{T}^2$
Boracic acid	22 ?	269·65	$\ddot{B}$
— acid crystallized (2 water)	40		
Borax (8 water)	158		
Boron	6 ?	69·655	B
Cadmium	56	1393·54	Cd
— carbonate	86	2144·20	$\ddot{C}^d\,\ddot{C}^2$
— chloride	92	2278·84	$\ddot{C}^d\,\ddot{M}^2$
— iodide	181	4526·94	$\ddot{C}^d\,\ddot{I}^2$
— nitrate	118	2948·06	$\ddot{C}^d\,\overset{:\cdot:}{N}^2$
— oxide	64	1593·54	$\ddot{C}^d$
— phosphate	92	2485·84	$\ddot{C}^d\,\overset{:\cdot:}{P}^2$
— phosphuret	68		
— sulphate	104	2595·86	$\ddot{C}^d\,\dddot{S}^2$
— sulphuret	72	1795·86	$C^d\,S^2$
Calcium	20	512·06	Ca
— chloride	56	1397·36	$\ddot{Ca}\,\ddot{M}^2$
— fluoride	36	987·09	$\ddot{Ca}\,\ddot{F}$
— iodide	145	3645·46	$\ddot{Ca}\,\ddot{I}^2$
— oxide (lime)	28	712·06	$\ddot{Ca}$
— phosphuret	32	904·36	Ca P ?
— sulphuret	36		

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Calomel	236	2974·25	$\dot{H}\ \ddot{M}$
Camphoric acid	?		
Carbon	6	75·33	C
— perchloride	120		
— protochloride	42		
— subchloride	48		
— hydrochloride	50		
— oxide	14	175·33	$\dot{C}$
— phosphuret	18		
— sulphuret	38	477·65	$C\ S^2$
Carbonic acid	22	275·33	$\ddot{C}$
— oxide	14		
Carburet of azote	26		
— sulphur	38		
— phosphorus	18		
Carburetted hydrogen	8	101·86	$H^4\ C$
Cerium	46 ?	1149·44	Ce
Chloric acid	76		
Chlorine	36	221·325	M
Chromium	28	703·64	Ch
— deutoxide	44	1103·64	$\overset{:}{Ch}$
— oxide	36	1003·64	$\overset{\cdots}{Ch}$
Cobalt	26	738·00	Co
— acetate	84	2220·2	$\ddot{C}o\ \bar{A}^2$
— arseniate	96	2378·77	$\ddot{C}o\ \overset{:\cdot:}{A}s$
— benzoate	154	3957·10	$\ddot{C}o\ \bar{B}^2$
— borate	56	1477·31	$\ddot{C}o\ \ddot{B}^2$
— carbonate	56	1488·66	$\ddot{C}o\ \ddot{C}^2$
— chloride	62	1623·3	$\ddot{C}o\ \ddot{M}^2$
— citrate	92	2393·7	$\ddot{C}o\ \bar{C}^2$
— iodide	151	3871·4	$\ddot{C}o\ \ddot{I}^2$
— nitrate	88	2292·52	$\ddot{C}o\ \overset{:::}{N}^2$
— oxalate	70	1841·54	$\ddot{C}o\ \bar{O}^2$
— peroxide	?	1038·00	$\overset{\cdots}{Co}$
— phosphate	62	1830·30	$\ddot{C}o\ \overset{:\cdot:}{P}$
— phosphuret	38		
— protoxide	34	938·00	$\ddot{C}o$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Cobalt, sulphate (dry) . . .	74	1940·32	$\ddot{Co}\,\dddot{S}^2$
— crystallized (7 water) . . .	137		
— sulphuret	42	1140·32	$Co\,S^2$
— tartrate	101	2606·98	$\ddot{Co}\,\overline{T}^2$
Columbium	144 ?	1823·15	Ta
Copper	64	791·39	Cu
— acetate	130	2273·6	$\ddot{Cu}\,\overline{A}^2$
— crystallized (6 w. com. verdigris)	184		
— binacetate	180		
— crystallized (3 w. dist. verdigris)	207		
— subacetate (1 acid 2 base) . .	210		
— carbonate (unhydrous) . .	102	1542·05	$\ddot{Cu}\,\ddot{C}^2$
— (2 water malachite) . . .	111		
— iodide	189	3924·79	$\ddot{Cu}\,\ddot{I}^2$
— perchloride	136	1676·69	$\ddot{Cu}\,\ddot{M}^2$
— pernitrate	188	2345·91	$\ddot{Cu}\,\overset{:::}{N}^2$
— persulphate	160	1993·71	$\ddot{Cu}\,\dddot{S}^2$
— crystallized (10 water) . .	250		
— perphosphate	136	1883·69	$\ddot{Cu}\,\overset{:\cdot:}{P}$
— phosphuret	76		
— protochloride	100	1234·04	$\overset{:}{Cu}\,\ddot{M}$
— protoxide	72	891·39	$\dot{Cu}$
— peroxide	80	991·39	$\ddot{Cu}$
— sulphuret	80	992·55	Cu S
Corrosive sublimate . . .	272		
Cyanogen	26		
Fluorine	16	75·03	Fl
Glucina	26	962·56	$\dddot{Be}$
Glucinum	18	662·56	Be
Gold	200	2486·00	Au
— chloride	236	3813·95	$\dddot{Au}\,\ddot{M}^3$
— iodide	325		
— protoxide 1 + 1 = . . .	208	2586·00	$\dot{Au}$
— peroxide 1 + 3 = . . .	224	2786·00	$\dddot{Au}$
— sulphuret 1 + 3 = . . .	248	3089·48	$Au\,S^3$
— chloride of, and sodium (dry) .	296		
— crystallized (8 water) . . .	368		

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Hydrogen	1	6·2177	H
Iodine	125	1266·7	I
Iron	28	678·43	Fe
— protochloride	64	1563·73	$\ddot{Fe}\,\ddot{M}^2$
— perchloride	82	2006·38	$\dddot{Fe}\,\ddot{M}^3$
— peroxide	40	978·43	$\dddot{Fe}$
— protoxide	36	878·43	$\ddot{Fe}$
— sulphate (dry)	76	2481·91	$\dddot{Fe}\,\dddot{S}^3$
— crystallized (7 water)	139		
— persulphuret	60	1483·07	$Fe\,S^4$
— protosulphuret	44	1080·75	$Fe\,S^2$
Lead	104	2589·00	Pb
— acetate	162	4071·2	$\ddot{Pb}\,\overline{A}^2$
— crystallized (3 water)	189		
— sub-binacetate	274		
— sub-tritacetate	386	9649·2	$\ddot{Pb}^3\,\overline{A}^2$
— arseniate	174	4229·77	$\ddot{Pb}\,\overset{:::}{As}$
— benzoate	232	5908·10	$\ddot{Pb}\,\overline{B}^2$
— borate	134	3328·31	$\ddot{Pb}\,\ddot{B}^2$
— carbonate	134	3339·33	$\ddot{Pb}\,\ddot{C}^2$
— chlorate	188		
— chloride	140	3474·3	$\ddot{Pb}\,\ddot{M}^2$
— chromate	164	4092·64	$\ddot{Pb}\,\overset{:::}{Ch}$
— citrate	170	4244·70	$\ddot{Pb}\,\overline{C}^2$
— deutoxide	116	2889·00	$\dddot{Pb}$
— iodate	277	5722·4	$\ddot{Pb}\,\ddot{I}^2$
— iodide	229	5722·4	$\ddot{Pb}\,\ddot{I}^2$
— malate	182		
— molybdate	184	4582·6	$\ddot{Pb}\,\dddot{Mo}^2$
— nitrate	166	4143·52	$\ddot{Pb}\,\overset{:::}{N}^2$
— oxalate	146	3692·54	$\ddot{Pb}\,\overline{O}^2$
— peroxide	120	2989·00	$\ddddot{Pb}$
— phosphate	140	3681·39	$\ddot{Pb}\,\overset{:::}{P}$
— phosphite	132	3481·39	$\ddot{Pb}\,\dddot{P}$
— phosphuret	116		
— protoxide	112	2789·00	$\ddot{Pb}$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Lead, succinate	162	4044·70	$\ddot{Pb}\,\bar{S}^2$
— sulphate	152	3791·32	$\ddot{Pb}\,\dddot{S}^2$
— sulphite	144	3591·32	$\ddot{Pb}\,\ddot{S}^2$
— sulphuret	120	2991·32	$Pb\,S^2$
— tartrate	179	4457·98	$\ddot{Pb}\,\bar{T}^2$
Lime	28	712·06	$\ddot{Ca}$
— acetate	78	1994·3	$\ddot{Ca}\,\bar{A}^2$
— arseniate	90	2152·83	$\ddot{Ca}\,\overset{:\cdot:}{As}$
— benzoate	148	3731·16	$\ddot{Ca}\,\bar{B}^2$
— biphosphate	84	2496·66	$\ddot{Ca}\,\overset{:\cdot:}{P}^2$
— borate	50 ?	1251·37	$\ddot{Ca}\,\ddot{B}^2$
— carbonate	50	1262·72	$\ddot{Ca}\,\ddot{C}^2$
— chlorate	104	2597·36	$\ddot{Ca}\,\overset{:::::}{M}^2$
— chloride	64	1397·36	$\ddot{Ca}\,\ddot{M}^2$
— citrate	86	2167·76	$\ddot{Ca}\,\bar{C}^2$
— chromate	80	2015·70	$\ddot{Ca}\,\overset{:::}{Ch}$
— hydrate	37	936·98	$\ddot{Ca} + 2Aq$
— iodate	193	4845·46	$\ddot{Ca}\,\overset{:::::}{I}^2$
— muriate crystallized (5 water)	110		
— oxalate	64	1615·58	$\ddot{Ca}\,\bar{O}^2$
— phosphate	56	1604·36	$\ddot{Ca}\,\overset{:\cdot:}{P}$
— phosphite	48	1404·36	$\ddot{Ca}\,\dddot{P}$
— succinate	78	1967·76	$\dddot{Ca}\,\bar{S}^2$
— sulphate	68	1714·36	$\ddot{Ca}\,\dddot{S}^2$
— crystallized (2 water)	86		
— sulphite	60	1514·38	$\ddot{Ca}\,\ddot{S}^2$
— tartrate	95	2381·04	$\ddot{Ca}\,\bar{T}^2$
— tungstate	148	3727·44	$\ddot{Ca}\,\dddot{W}^2$
Lithia	18	455·63	$\ddot{L}$
— carbonate	40	1006·29	$\ddot{L}\,\ddot{C}^2$
— nitrate	72	1810·15	$\ddot{L}\,\overset{:\cdot:}{N}^2$
— phosphate	46	1347·93	$\ddot{L}\,\overset{:\cdot:}{P}$
— sulphate	58	1457·95	$\ddot{L}\,\dddot{S}^2$
Lithium	10	255·63	L
— chloride	46	1140·93	$\ddot{L}\,\ddot{M}^2$
— iodide	135	3389·63	$\ddot{L}\,\ddot{I}^2$
— sulphuret	26		

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Magnesia	20	516·72	$\ddot{\mathrm{Mg}}$
— ammonia-phosphate . . .	93		
— borate ?	42	1056·03	$\ddot{\mathrm{Mg}}\ \ddot{\mathrm{B}}$
— carbonate	42	1067·38	$\ddot{\mathrm{Mg}}\ \ddot{\mathrm{C}}^2$
— hydrate	29	741·59	$\ddot{\mathrm{Mg}} + 2\mathrm{Aq}$
— muriate	57		
— nitrate	74	1871·24	$\ddot{\mathrm{Mg}}\ \overset{:\cdot:}{\mathrm{N}}^2$
— phosphate	48	1409·02	$\ddot{\mathrm{Mg}}\ \overset{:\cdot:}{\mathrm{P}}$
— sulphate (dry) . . .	60	1519·04	$\ddot{\mathrm{Mg}}\ \dddot{\mathrm{S}}^2$
— crystallized (7 water) . .	123		
— tartrate	87	2185·70	$\ddot{\mathrm{Mg}}\ \bar{\mathrm{T}}^2$
Magnesium	12	316·72	Mg
— chloride	48	1202·02	$\ddot{\mathrm{Mg}}\ \ddot{\mathrm{M}}^2$
— iodide	137	3450·12	$\ddot{\mathrm{Mg}}\ \ddot{\mathrm{I}}^2$
— phosphuret	24		
— sulphuret	28		
Manganese	28	711·57	Mn
— acetate	86	2935·0	$\dddot{\mathrm{Mn}}\ \bar{\mathrm{A}}^3$
— benzoate, r.	156	5540·22	$\dddot{\mathrm{Mn}}\ \bar{\bar{\mathrm{B}}}^3$
— carbonate	58	1462·33	$\ddot{\mathrm{Mn}}\ \ddot{\mathrm{C}}^2$
— chlorate	112	2798·87	$\ddot{\mathrm{Mn}}\ \overset{::::}{\mathrm{M}}^2$
— chloride	64	1596·87	$\ddot{\mathrm{Mn}}\ \ddot{\mathrm{M}}^2$
— citrate	94	2467·27	$\ddot{\mathrm{Mn}}\ \bar{\mathrm{C}}^2$
— deutoxide	40	1011·57	$\underset{\cdot}{\dddot{\mathrm{Mn}}}$
— oxalate	72	2306·88	$\dddot{\mathrm{Mn}}\ \bar{\mathrm{O}}^3$
— peroxide	44	1111·57	$\overset{::}{\mathrm{Mn}}$
— phosphate	64	4700·04	$\dddot{\mathrm{Mn}}^2\ \overset{:\cdot:}{\mathrm{P}}^3$
— phosphuret	40		
— protoxide	36	911·57	$\ddot{\mathrm{Mn}}$
— succinate	86	2895·12	$\dddot{\mathrm{Mn}}\ \bar{\mathrm{S}}^3$
— sulphate	76	2515·05	$\dddot{\mathrm{Mn}}\ \dddot{\mathrm{S}}^3$
— tartrate	103	2580·55	$\ddot{\mathrm{Mn}}\ \bar{\mathrm{T}}^2$
Mercury	200	2531·60	Hg
— bipersulphate	296		
— bisulphuret	232	2933·92	$\mathrm{Hg}\ \mathrm{S}^2$
— bicyanuret	252		
— perchloride	272	3416·9	$\ddot{\mathrm{Hg}}\ \ddot{\mathrm{M}}^2$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Mercury, periodide	450	5665·0	$\ddot{\mathrm{Hg}}\,\ddot{\mathrm{I}}^{2}$
— pernitrate	324	4086·12	$\ddot{\mathrm{Hg}}\,\overset{:::}{\mathrm{N}}^{2}$
— peroxide	216	2731·6	$\ddot{\mathrm{Hg}}$
— perphosphate	272	3623·9	$\ddot{\mathrm{Hg}}\,\overset{:\cdot:}{\mathrm{P}}$
— persulphate	256	3633·92	$\dot{\mathrm{Hg}}\,\dddot{\mathrm{S}}^{2}$
— protochloride	236	2974·25	$\dot{\mathrm{H}}\,\ddot{\mathrm{M}}$
— protonitrate	262	3308·86	$\dot{\mathrm{Hg}}\,\overset{:::}{\mathrm{N}}$
— protosulphate	248	3132·76	$\dot{\mathrm{Hg}}\,\dddot{\mathrm{S}}$
— protoxide	208	2631·6	$\dot{\mathrm{Hg}}$
Molybdenum	48	596·80	Mo
— protoxide	56	696·80	$\dot{\mathrm{Mo}}$
Nickel	29	739·51	Ni
— acetate	87	2221·7	$\ddot{\mathrm{Ni}}\,\bar{\mathrm{A}}^{2}$
— arseniate	99	2380·28	$\ddot{\mathrm{Ni}}\,\overset{:\cdot:}{\mathrm{As}}$
— benzoate	157		
— borate	59		
— carbonate	59	1490·17	$\ddot{\mathrm{Ni}}\,\ddot{\mathrm{C}}^{2}$
— chloride	65	1624·81	$\ddot{\mathrm{Ni}}\,\ddot{\mathrm{M}}^{2}$
— citrate	95	2395·21	$\ddot{\mathrm{Ni}}\,\bar{\mathrm{C}}^{2}$
— iodide	164	3872·91	$\ddot{\mathrm{Ni}}\,\ddot{\mathrm{I}}^{2}$
— nitrate	91	2294·03	$\ddot{\mathrm{Ni}}\,\overset{:::}{\mathrm{N}}^{2}$
— oxalate	73	1843·05	$\ddot{\mathrm{Ni}}\,\bar{\mathrm{O}}^{2}$
— peroxide	?	1039·51	$\dddot{\mathrm{Ni}}$?
— phosphate	65	1831·81	$\ddot{\mathrm{Ni}}\,\overset{:\cdot:}{\mathrm{P}}^{2}$
— phosphuret	41		
— protoxide	37	939·51	$\ddot{\mathrm{Ni}}$
— sulphate (dry)	77	1941·83	$\ddot{\mathrm{Ni}}\,\dddot{\mathrm{S}}^{2}$
— crystallised (7 water)	140		
— sulphuret	45	1141·83	$\mathrm{Ni}\,\mathrm{S}^{2}$
— tartrate	104	2608·49	$\ddot{\mathrm{Ni}}\,\bar{\mathrm{T}}^{2}$
Nitric oxide	30	377·26	$\dddot{\mathrm{N}}$
Nitrogen	14	177·26	$\dot{\mathrm{N}}$
Nitrous oxide	22	277·26	$\ddot{\mathrm{N}}$
Olefiant gas	7		
Osmium	?		Os ?
— oxide	?		?
Oxygen	8	100·00	O

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Palladium	?	1407·50	Pa
— oxide	?	1607·50	$\ddot{Pa}$
Phosphorus	12	392·30	P
— carburet	18		
— chloride	48		
— perchloride	84		
— sulphuret	28		
Platinum	96	1215·23	Pt
— ammonia-muriate . . .	196		
— perchloride	142	2100·53	$\ddot{Pt}\,\ddot{M}^2$
— peroxide	112	1415·23	$\ddot{Pt}$
— bi-phosphuret	120		
— bisulphuret	128		
Potash (dry)	48	1179·83	$\ddot{K}$
— acetate	98	2462·0	$\ddot{K}\,\bar{A}^2$
— arseniate	110	2620·60	$\ddot{K}\,\overset{::}{As}$
— arsenite	102	3661·37	$\ddot{K}\,\dddot{As}^2$
— benzoate	168	4198·93	$\ddot{Ka}\,\bar{B}^2$
— bicarbonate	92	2281·15	$\ddot{K}\,\ddot{C}^4$
— crystallized (1 water) . .	101		
— bichromate	152		
— binarseniate	172	4061·37	$\ddot{K}\,\overset{:\cdot:}{As}^2$
— binoxalate	120	2986·91	$\ddot{K}\,\bar{O}^4$
— biphosphate	104	2964·43	$\ddot{K}\,\overset{:\cdot:}{P}^2$
— bisulphate	128	3184·47	$\ddot{K}\,\ddot{S}^4$
— crystallized (1 water) . .	137		
— bitartrate	182	4517·79	$\ddot{K}\,\bar{T}^4$
— crystallized (1 water) . .	191		
— borate	70 ?	1719·14	$\ddot{K}\,\ddot{B}^2$
— carbonate	70	1730·49	$\ddot{K}\,\ddot{C}^2$
— chlorate	124	3065·13	$\ddot{K}\,\overset{::::}{M}^2$
— chromate	100	2483·47	$\dot{K}\,\overset{:::}{Ch}$
— citrate	106	2635·5	$\ddot{K}\,\bar{C}^4$
— hydrate	57	1404·70	$\ddot{K} + 2Aq$
— iodate	213	5313·23	$\ddot{K}\,\overset{::::}{I}^2$
— molybdate	120	2973·43	$\ddot{K}\,\dddot{Mo}^2$
— nitrate	102	2534·85	$\ddot{K}\,\overset{:::}{N}^2$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Potash, oxalate	84	2083·37	$\ddot{K}\,\bar{O}^{2}$
— phosphate	76	2072·13	$\ddot{K}\,\overset{\cdot\cdot\cdot\cdot\cdot}{P}$
— quadroxalate	192	4793·99	$\ddot{K}\,\bar{O}^{8}$
— succinate	98	2435·53	$\ddot{K}\,\bar{S}^{2}$
— sulphate	88	2182·15	$\ddot{K}\,\dddot{S}^{2}$
— sulphite	80	1982·15	$\ddot{K}\,\ddot{S}^{2}$
— tartrate	115	2848·81	$\ddot{K}\,\bar{T}^{2}$
— tungstate	168	4195·21	$\ddot{K}\,\dddot{W}^{2}$
Potassium	40	979·83	K
— chloride	76	1865·13	$\ddot{K}\,\ddot{M}^{2}$
— iodide	165	4113·23	$\ddot{K}\,\ddot{I}^{2}$
— peroxide	64	1579·83	$\overset{\cdot\cdot\cdot\cdot\cdot\cdot}{K}$
— phosphuret	52	1372·13	$K\,P^{2}$
— protoxide (dry)	48	1179·83	$\ddot{K}$
— sulphuret	56	1382·15	$K\,S^{2}$
Rhodium	44 ?	1500·10	R
— peroxide	60	1800·10	$\dddot{R}$
— protoxide	52 ?	1600·10	$\dot{R}$
Selenium ?	41	495·91	Se
Silica	16	596·42	$\dddot{Si}$
Silicium	8	296·42	Si
Silver	110	2703·21	Ag
— acetate	168	4185·45	$\ddot{A}g\,\bar{A}^{2}$
— arseniate	180	4343·98	$\ddot{A}g\,\overset{\cdot\cdot\cdot\cdot\cdot}{As}$
— arsenite	172	5384·75	$\ddot{A}g\,\dddot{As}^{2}$
— benzoate	238	5922·31	$\ddot{A}g\,\bar{B}e$
— borate ?	140	3442·52	$\ddot{A}g\,\ddot{B}^{2}$
— carbonate	140	3453·87	$\ddot{A}g\,\ddot{C}^{2}$
— chlorate	194	4788·51	$\ddot{A}g\,\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{M}^{2}$
— chloride	146	3588·51	$\ddot{A}g\,\ddot{M}^{2}$
— chromate	170	4206·85	$\ddot{A}g\,\overset{\cdot\cdot\cdot\cdot\cdot\cdot}{Ch}$
— citrate	176	4358·91	$\ddot{A}g\,\bar{C}^{2}$
— iodate	283	7036·61	$\ddot{A}g\,\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{I}^{2}$
— iodide	235	5836·61	$\ddot{A}g\,\ddot{I}^{2}$
— molybdate	190	4696·81	$\ddot{A}g\,\dddot{Mo}^{2}$
— nitrate	172	4257·73	$\ddot{A}g\,\overset{\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot}{N}^{2}$
— oxalate	154	3806·75	$\ddot{A}g\,\bar{O}^{2}$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Silver, oxide	118	2903·21	$\ddot{Ag}$
— phosphate	146	3795·51	$\ddot{Ag}\,\overset{:\cdot:}{P}$
— sulphate	158	3905·53	$\ddot{Ag}\,\dddot{S}^{2}$
— sulphite	150	3705·53	$\ddot{Ag}\,\ddot{S}^{2}$
— sulphuret	126	3105·53	$Ag\,S^{2}$
— tartrate	185	4572·19	$\ddot{Ag}\,\bar{T}^{2}$
— tungstate	238	5918·59	$\ddot{Ag}\,\dddot{W}^{2}$
Soda	32	781·84	Na
— acetate	82	2064·0	$\ddot{Na}\,\bar{A}^{2}$
— crystallized (6 water)	136		
— arseniate	94	2222·61	$\ddot{Na}\,\overset{:\cdot:}{As}$
— arsenite	86	3263·38	$\ddot{Na}\,\dddot{As}^{2}$
— benzoate	152	3800·94	$\ddot{Na}\,\bar{B}^{2}$
— bicarbonate	76	1883·16	$\ddot{Na}\,\ddot{C}a^{4}$
— borate ?	54	1321·15	$\ddot{Na}\,\ddot{B}^{2}$
— carbonate (dry)	54	1332·50	$\ddot{Na}\,\ddot{C}^{2}$
— crystallized (11 water)	153		
— chlorate	108	2667·14	$\ddot{Na}\,\overset{::::}{M}^{2}$
— chromate	84	2085·48	$\ddot{Na}\,\overset{:::}{Ch}$
— citrate	90	2237·54	$\ddot{Na}\,\bar{C}^{2}$
— hydrate	41	1006·71	$\ddot{Na}+2Aq$
— iodate	197	4915·24	$\ddot{Na}\,\overset{::::}{I}^{2}$
— molybdate	104	2575·44	$\ddot{Na}\,\dddot{Mo}^{2}$
— nitrate	86	2136·36	$\ddot{Na}\,\overset{:::}{N}^{2}$
— oxalate	68	1685·38	$\ddot{Na}\,\bar{O}^{2}$
— succinate	82	2037·54	$\ddot{Na}\,\bar{S}^{2}$
— sulphate (dry)	72	1784·16	$\ddot{Na}\,\dddot{S}^{2}$
— crystallized (10 water)	162		
— sulphite	64	1584·16	$\ddot{Na}\,\ddot{S}^{2}$
— tartrate	99	2450·80	$\ddot{Na}\,\dddot{T}^{2}$
— and potash	214		
Sodium	24	581·84	Na
— chloride	60	1467·14	$\ddot{Na}\,\ddot{M}^{2}$
— iodide	149	3715·24	$\ddot{Na}\,\ddot{I}^{2}$
— phosphuret	36		
— peroxide	36	881·84	$\dddot{Na}$
— protoxide	32	781·84	$\ddot{Na}$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Sodium, sulphuret	40	984·16	$\mathrm{Na\ S^2}$
Starch ?	142		
Strontia	52	1294·60	$\ddot{\mathrm{Sr}}$
— acetate	102	2576·8	$\ddot{\mathrm{Sr}}\ \overline{\mathrm{A}}^2$
— borate ?	74	1833·91	$\ddot{\mathrm{Sr}}\ \ddot{\mathrm{B}}^2$
— carbonate	74	1845·26	$\ddot{\mathrm{Sr}}\ \ddot{\mathrm{C}}^2$
— citrate	110	2750·3	$\ddot{\mathrm{Sr}}\ \overline{\mathrm{C}}^2$
— hydrate	61	1521·18	$\ddot{\mathrm{Sr}} + 2\mathrm{Aq}$
— muriate, crystallized (5 water)	134		
— oxalate	88	2198·14	$\ddot{\mathrm{Sr}}\ \overline{\mathrm{O}}^2$
— phosphate	80	2186·90	$\ddot{\mathrm{Sr}}\ \overset{\vdots\cdot\vdots}{\mathrm{P}}$
— sulphate	92	2296·92	$\ddot{\mathrm{Sr}}\ \dddot{\mathrm{S}}^2$
— tartrate	119	2963·58	$\ddot{\mathrm{Sr}}\ \overline{\mathrm{T}}^2$
Strontium	44	1094·60	Sr
— chloride	80	1979·91	$\ddot{\mathrm{Sr}}\ \ddot{\mathrm{M}}^2$
— iodide	169	4228·0	$\ddot{\mathrm{Sr}}\ \ddot{\mathrm{I}}^2$
— phosphuret	56		
— sulphuret	60		
Sugar	?		
Sulphur	16	201·16	S
— carburet	38	477·65	$\mathrm{C\ S^2}$
— chloride	52		
— iodide	141		
— phosphuret	28		
Sulphuretted hydrogen	17	213·60	$\mathrm{H^2\ S}$
Tannin ?	71		
Tellurium	38	806·45	Te
— chloride	74	1691·75	$\ddot{\mathrm{Te}}\ \ddot{\mathrm{M}}^2$
— oxide	46	1006·45	$\ddot{\mathrm{Te}}$
Tin	58	1470·58	Sn
— bisulphuret	90	2275·22	$\mathrm{Sn\ S^4}$
— iodide	183	4603·98	$\ddot{\mathrm{Sn}}\ \ddot{\mathrm{I}}^2$
— peroxide	74	1870·58	$\ddddot{\mathrm{Sn}}$
— protoxide	66	1670·58	$\ddot{\mathrm{Sn}}$
— perchloride	130	3241·18	$\ddddot{\mathrm{Sn}}\ \ddot{\mathrm{M}}^4$
— protochloride	94	2355·88	$\ddot{\mathrm{Sn}}\ \ddot{\mathrm{M}}^2$

Substances.	Hydrogen = 1.	Oxygen = 100.	Symbols.
Tin, sulphuret	74	1872·90	$\mathrm{Sn}\,\mathrm{S}^2$
— phosphuret	70		
Titanium	?	?	Ti
Tungsten	96	1207·69	W
Tungstic acid	120	1507·69	$\dddot{\mathrm{W}}$
Uranium	?	3146·86	U
— oxide	?	3846·86	$\ddot{\mathrm{U}}$
Uric acid	45 ?		
Water	9	112·4384	Aq
Yttria	40	1005·14	$\ddot{\mathrm{Y}}$
Yttrium ?	32	805·14	Y
Zinc	34	806·45	Zn
— acetate	92	2288·7	$\ddot{\mathrm{Zn}}\,\bar{\mathrm{A}}^2$
— arseniate	104	2447·22	$\ddot{\mathrm{Zn}}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{As}}$
— benzoate	162	4025·56	$\ddot{\mathrm{Zn}}\,\bar{\mathrm{B}}^2$
— borate	64	1645·76	$\ddot{\mathrm{Zn}}\,\ddot{\mathrm{b}}^2$
— carbonate	64	1557·11	$\ddot{\mathrm{Zn}}\,\ddot{\mathrm{C}}$
— chlorate	118	2891·75	$\ddot{\mathrm{Zn}}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{M}}^2$
— chloride	70	1691·75	$\ddot{\mathrm{Zn}}\,\ddot{\mathrm{M}}^2$
— citrate	100	2462·15	$\ddot{\mathrm{Zn}}\,\bar{\mathrm{C}}^2$
— iodate	207	5139·85	$\ddot{\mathrm{Zn}}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{I}}^2$
— iodide	159	3939·85	$\ddot{\mathrm{Zn}}\,\ddot{\mathrm{I}}^2$
— nitrate	96	2360·97	$\ddot{\mathrm{Zn}}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}^2$
— oxalate	78	1909·99	$\ddot{\mathrm{Zn}}\,\bar{\mathrm{O}}^2$
— oxide	42	1006·45	$\ddot{\mathrm{Zn}}$
— phosphate	70	1898·75	$\ddot{\mathrm{Zn}}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$
— phosphuret	46		
— succinate	92	2262·15	$\ddot{\mathrm{Zn}}\,\bar{\mathrm{S}}^2$
— sulphate (dry)	82	2008·77	$\ddot{\mathrm{Zn}}\,\dddot{\mathrm{S}}^2$
— crystallized (6 water)	136		
— sulphite	74	1808·77	$\ddot{\mathrm{Zn}}\,\ddot{\mathrm{S}}^2$
— tartrate	110	2675·43	$\ddot{\mathrm{Zn}}\,\bar{\mathrm{T}}^2$
Zirconia	45 ?	?	$\mathrm{Zr}\,\mathrm{Ox}$
Zirconium	37 ?	?	Zr

ERITROGENE. The name given by Sig. Bizio of Venice to a new animal product found in the gall bladder of a person who died of jaundice. It is of a green colour, tasteless, smelling like putrid fish, transparent, flexible, unctuous, easily scratched or cut, and which crystallizes in the form of rhomboidal parallelopipeds. Its sp. gr. is 1.57. It fuses at 110° F., appearing like an oil; when slowly cooled, it crystallizes on solidifying. When heated to 122° F. it volatilizes, giving in contact with the atmosphere, a purple vapour. Its name was given in consequence of the power it possessed of being transformed into a red matter, and of giving a purple vapour. It does not dissolve in water or ether, but with facility in alcohol. *Journal of Science*, xvi. 173.

ERLAMITE, a new mineral, discovered in 1818 by Briethaupt in the Saxon Erzgeberge, forming a part of the oldest gneiss formation. Its lustre is shining feebly, or dull. Streak shining, with a fatty lustre. Colour, light greenish grey; streak, white. Massive. Sometimes compact, sometimes in small and fine granular, distinct concretions. Fracture in some specimens foliated, in others splintery and even. Its structure is distinctly crystalline; but no specimen has yet been observed which admitted of regular cleavages. Hardness between that of apatite and actynolite. Sp. gr. from 3· to 3.1. Before the blowpipe it melts easily into a slightly coloured, transparent, compact pearl, and resembles gehlenite more than any other mineral. According to the analysis of Professor Gmelin, it is composed of

Silica, . .	53·160
Alumina, . .	14·034
Lime, . .	14.397
Soda, . .	2.611
Magnesia, .	5.420
Oxide of iron, .	7·138
Oxide of manganese,	0.639
Volatile matter, .	0.606
Loss, . .	1.995
	100·000

Schweigger und Meinecke, Jahrbuch der Chemie und Physik, vii. 76.

ESSENCES. Several of the volatile or essential oils are called essences by the perfumers.

ETHER. A very volatile fluid, produced by the distillation of alcohol with an acid.

When strong sulphuric acid is poured upon an equal weight of alcohol, the fluids unite with a hissing noise and the production of heat, at the same time that a fragrant vegetable smell is perceived, resembling that of apples. It is much better and safer, however, to add the acid by small portions at a time, at such intervals as that no perceptible heat may be produced. The mixture may be made in a glass retort, and the distillation performed by regulated heat on a sand-bath, a large tubulated receiver being previously well adapted, and kept cool by immersion in water, or the frequent application of wet cloths. A bent glass tube luted to the tubulure of the receiver, and having its extremity immersed in a little water or mercury, will allow the gases to escape, and confine the condensible vapour. The first product is a fragrant spirit of wine, which is followed by the ether, as soon as the fluid in the retort begins to boil. At this period, the upper part of the receiver is covered with large distinct streams of the fluid, which run down its sides. After the ether has passed over, sulphurous acid arises, which is known by its white fume and peculiar smell. At this period the receiver must be unluted and removed, care being taken to avoid breathing the penetrating fumes of the acid; and the fire must at the same time be moderated, because the residue in the retort is disposed to swell. A light yellow oil, called sweet oil of wine, comes over after the ether, and is succeeded by black and foul sulphuric acid. The residue varies in its properties, according to the management of the heat. If the fire be much increased toward the end of the process, the sulphurous acid that comes over will be mixed with vinegar.

The ether comes over mixed with alcohol and some sulphurous acid. It was usual to add some distilled water to this product, which occasioned the ether to rise to the top. Rectification is absolutely necessary, if the ether have a sulphurous smell; and this is indeed the better method in all cases, because the water added in the old method always absorbs about one-tenth part of its weight of ether, which cannot be recovered without having recourse to distillation; and also because the ether is found to absorb a quantity of the water. Previous to the rectification, a small quantity of black oxide of manganese should be added, shaking the mixture occasionally during 24 hours. Prout prefers clean slaked lime, as recommended by Woolfe; observing that the bottle must not be above three parts filled, and that it must be moved about in cold water for some minutes before the cork is taken out.

The inexperienced chemist must be reminded, that the extreme inflammability of alcohol, and still more of ether; the danger of explosion which attends the sudden mixture and agitation of concentrated acids and alcohol; and the suffocating effect of the elastic fluids, which might fill the apartment if inadvertently disengaged; are all circumstances which require cautious management.

Sulphuric ether is a very fragrant, light, and volatile fluid. Its evaporation produces extreme cold. It is highly inflammable, burns with a more luminous flame than alcohol, which is of a deep blue, and emits more smoke. At 46° below 0 of Fahr. it becomes solid. It dissolves essential oils and resins, and camphor very plentifully. By long digestion it dissolves 1-13th of sulphur in the light, and 1-17th in the dark. Mixed with the muriatic solution of gold, it retains a portion of the metal in solution for some time.

To give sulphuric ether its utmost purity, we must add to the common purified ether dry subcarbonate of potash in powder, till the last portions are not wetted, and draw off the ether by distillation. Its sp. gr. will fall from 0·775 to 0·746. Being thus deprived of its water, it must next be freed from alcohol, by digesting it on dry muriate of lime, and decanting the supernatant liquid, which is ether of sp. gr. 0.632 at 60°, according to Lowitz. Distillation increases its density to 0·7155 at 68°, according to M. T. de Saussure.

Ether boils in the atmosphere at 98° Fahr. and *in vacuo* at — 20°. The density of its vapour, as determined by M. Gay Lussac, is 2.586, that of air being 1. Ether admitted to any gas standing over mercury doubles its bulk at atmospheric temperatures. If oxygen be thus expanded with ether, and then mixed with three times its bulk of pure oxygen, on being kindled it explodes, forming carbonic acid and water. By detonating such a mixture M. de Saussure inferred ether to consist of

Hydrogen,	14·40
Carbon,	67·98
Oxygen,	17·62
	100·00

These proportions per cent., correspond to

Olefiant gas,	80.05
Water,	19.95
	100.00

Or very nearly 5 primes olefiant gas, consisting of 5 carbon + 5 hydrogen;

Or (0·750 + 0·125) × 5 = 4.375
1 prime water, or 1 hydrogen + 1 oxygen, } = 1.125
5.500

Or 6 hydrogen + 5 carbon + 1 oxygen.

By passing ether through a red-hot porcelain tube, it is resolved into heavy inflammable air, a viscid volatile oil, a little concrete oil, and charcoal and water.

Ten parts of water combine with one of ether. Sulphuric acid converts ether into sweet oil of wine. If a very little ether be thrown into a large bottle filled with chlorine, a white vapour soon rises, followed by explosion and flame. Charcoal is deposited, and carbonic acid gas formed.

If we apply to ether that principle of research invented by M. Gay Lussac, and so successfully applied by him to iodine and prussic acid, we shall find that,

2 volumes of olefiant gas, = 0·9722 × 2 = 1·9444
1 do vapour of water, = 0·6249

Condensed into one volume of vapour of ether, = 2·5693
Which is very nearly the experimental sp. gr. = 2·5860

On this view, the vapour of ether contains one-half of the combined water that the vapour of alcohol does.

But two volumes of olefiant gas consist of four volumes of hydrogen, and four of carbon, in a condensed state; and one volume of aqueous vapour consists of one volume of hydrogen, and half a volume of oxygen. Hence the ratio of the weights of the constituents will become, on the hypothetical oxygen scale, in which half a volume of oxygen represents one atom,

5 atoms	hydrogen,	= 0·125 × 5 =	0·625 ...	13·513
4	carbon,	= 0·750 × 4 =	3·000 ...	21·622
1	oxygen,	= 1·000 × 1 =	1.000 ...	64·865
			4.625	100.000

These proportions differ from those of M. de Saussure, in making the carbon more, and the oxygen less, than he found.

By my analysis, which was conducted with much care and often repeated, I found that ether purified in M. de Saussure's way, decomposed by peroxide of copper, was composed of

Carbon,	59.60	3 atoms	2.25 ..	60.00
Hydrogen,	13.30	4 do.	0.50 ..	13.33
Oxygen,	27.10	1 do.	1.00 ..	26.66
	100.00		3·75	100.00

$$\begin{array}{lcl} \text{Or 3 volumes olefiant gas} & = 3 \times 0{\cdot}9722 & = 2.9166 \\ \text{2 do. vapour of water} & = 2 \times 0.625 & = 1{\cdot}2500 \\ \hline & & 4.1666 \end{array}$$

The specific gravity of its vapour I did not experimentally determine; but from the smaller proportion of carbon in it than in the ether analysed by M. de Saussure, I presume the density must have been considerably less than 2·586. Probably the sp. gr. of the liquid ether examined by M. de Saussure was only 0.632; that of mine was 0.700.

Ethers, exactly the same with the sulphuric, may be obtained by passing alcohol through phosphoric and arsenic acids concentrated and heated.

Another kind of ethers are those which result from the combination of the alcohol with the acid employed to make them. Nine such ethers are known. Muriatic ether, nitric ether, hydriodic ether, acetic ether, benzoic ether, oxalic ether, citric ether, tartaric ether, gallic ether: the first four are more volatile than alcohol; the rest are much less so, for they boil with more difficulty than water.

Muriatic ether. It is formed by saturating alcohol with muriatic acid gas; or still better by mixing together equal bulks of alcohol and concentrated liquid muriatic acid, and heating the mixture in a glass retort connected with a Woolfe's apparatus. The first bottle should contain a quantity of water, at about 80° F.; the second should be surrounded with ice. From 10 ounces of acid, and an equal bulk of alcohol, 1.2 ounces of ether may be obtained.

Under the barometric pressure of 30 inches, this ether is always gaseous at 51°, and all higher temperatures. In the state of gas it is colourless, and without action on litmus or violets. Its odour is very strong, and analogous to that of sulphuric ether; its taste is perceptibly saccharine; and its sp. gr. compared to that of air is 2.219.

In the liquid state at 40° F., its sp. gr. is 0.874. Poured on the palm of the hand it immediately boils, and produces much cold.

According to MM. Colin and Robiquet, (*Annales de Chimie et de Physique*, i. p. 348.) one volume of muriatic ether passed through a porcelain tube, at a dull red heat, is resolved into a mixture of one volume olefiant gas, and one volume muriatic acid gas. By adding the density of

$$\begin{array}{lll} \text{Olefiant gas,} & = 0.9722 & \text{to that of} \\ \text{Muriatic acid gas,} & = 1.2840 & \\ \hline \text{We have the sum} & = 2.2562 & \end{array}$$

Which is nearly the sp. gr. of the vapour by experiment = 2.2190.

When a lighted taper is brought near the surface of this ether, it immediately takes fire, and burns with a greenish flame. Muriatic gas, carbonic acid, and water, result. Similar products are obtained by firing a mixture of its vapour with oxygen, either by the taper or electric spark. If the oxygen be to the vapour in the ratio of 3 to 1, a violent detonation takes place, which breaks common eudiometers.

Water dissolves of muriatic ether a volume equal to its own, at mean pressure and temperature. The solution has a sweet and cooling taste, analogous to that of peppermint. Although it be very soluble in alcohol, water separates the whole of it. Chlorine instantly decomposes muriatic ether. Nitrate of silver and protonitrate of mercury, two salts, which suddenly occasion precipitates in waters containing muriatic acid, either free or combined with a salifiable base, produce no immediate cloud with this ether. It is only after some hours contact that we begin to perceive an action; and even after three months, the muriatic acid is not completely thrown down. These experiments must be made in phials closed with well-ground stoppers.

The ether produced by treating certain muriates, especially the fuming muriate, or chloride of tin, with alcohol is muriatic ether. The only difference which exists between the former and this kind is, that the ether formed with the acid is a little more volatile than the ether made with the chlorides.

Nitric ether. This ether is prepared by distilling equal parts by weight of alcohol, and the aquafortis of commerce. After having introduced them into a retort capable of holding double the bulk, it must be put in connexion with a Woolfe's apparatus, of which the first bottle is empty, and the other four half filled with saturated brine. The whole bottles must be put into an oblong box, and surrounded with a mixture of snow and salt. We then apply a gentle heat from a charcoal chauffer. As soon as the liquor begins to boil, we must instantly withdraw the heat, and, if necessary, check the violence of the ebullition by the application of a moist sponge, or rag, to the retort. The operation is finished when it spontaneously ceases to boil. By this time the product forms a little more than one-third of the alcohol and acid employed.

But ether is not the sole product of the operation. We obtain also much protoxide of azote and water, a little azote, deutoxide of azote, carbonic acid gas, nitrous acid gas, acetic acid, and a substance easily carbonized. We are thus led to suppose that a portion of the alcohol is completely decomposed by the nitric acid; that it yields almost all its hydrogen to the oxygen of this acid; and that hence result all the products, besides the ether, whilst the alcohol and the nitrous acid unite to constitute the ether properly so called. The whole ether comes over as well as the azote, protoxide of azote, deutoxide of azote, and carbonic acid. As to the water, nitrous and acetic acids, they are disengaged only in part, as well as a portion of the alcohol and nitric acid which escape their reciprocal action. In fact, the easily charred matter remains in the retort along with a little acetic acid, about 78 parts of nitric acid, 60 of alcohol, and 284 of water, supposing that we had operated upon 500 parts of alcohol and as much dilute nitric acid.

It is because there is formed so great a quantity of gas, that the salt water and refrigeration are required. Without these precautions, the greater part of the ether would be carried off into the atmosphere; and, even with them, some is always lost.

On unluting the apparatus, there is found in the first bottle a large quantity of yellowish liquid, formed of much weak alcohol, of ether, with nitrous, nitric, and acetic acids. In the second, we find on the surface of the salt water a pretty thick stratum of ether, contaminated with a little acid and alcohol. In the third, a thinner layer of the same, and so on.

These layers are to be separated from the water by a long-necked funnel, mixed with the liquid of the first bottle, and redistilled from a retort by a gentle heat, into a receiver surrounded with ice. The first product is an ether, which may be entirely deprived of acid, by being placed in contact with cold quicklime in a phial, and decanted off it in about half an hour. From a mixture of about 500 parts of alcohol, and as much acid, about 100 parts of excellent ether may be procured.

Nitric ether in its ordinary state is a liquid of a yellowish-white colour. It has an odour analogous to that of the preceding ethers, but much stronger, so that its inhalation into the nostrils produces a species of giddiness. It does not redden litmus. Its taste is acrid and burning. Its sp. gr. is greater than that of alcohol, and less than that of water. It boils at 70° F., or at that temperature sustains a column equal to 30 inches of mercury. Poured into the hand, it immediately boils, and creates considerable cold. It is sufficient to grasp in our hands a phial containing it, to see bubbles immediately escape. It takes fire very readily, and burns quite away, with a white flame.

When agitated with 25 or 30 times its weight of water, it is divided into three portions. One, the smallest, is dissolved; another is converted into vapour; and a third is decomposed. The solution becomes suddenly acid; it assumes a strong smell of apples; and if, after saturating with potash the acid which it contains, it be subjected to distillation, we withdraw the alcohol, and obtain a residue formed of nitrate of potash. We see here that there is a separation of one part of the two bodies which constitute the ether. Left to itself in a well stopped bottle, the ether suffers a spontaneous change, for it becomes perceptibly acid. By distillation, acid is instantly developed, which shows that heat favours its decomposition. If, instead of exposing the nitric ether to a distilling heat, we make it traverse an ignited tube, it is completely decomposed. 41.5 parts of ether thus decomposed yielded 5.63 water, containing a little prussic acid; 0.40 of ammonia; 0.80 oil; 0.30 of charcoal; 0.75 carbonic acid; 29.9 of gases, formed of deutoxide of azote, azote, subcarburetted hydrogen, and oxide of carbon. The loss amounted to 3.72.

It is very slowly decomposed by potash. When combined with nitrous acid gas or acetic acid, so intimate a union is effected, that in making the compound pass through the most concentrated alkalis, only a small portion of its acid is separated. Nitric ether, from its great volatility, quintuples the volume of oxygen gas at ordinary temperatures.

We possess no exact analysis of nitrous ether.

Hydriodic ether. M. Gay Lussac, to whom the formation of this ether is due, obtained it by mixing together equal bulks of alcohol and a coloured hydriodic acid, sp. gr. 1.700, distilling the mixture by the heat of a water bath, and diluting with water the product which gradually collects in the receiver. The ether precipitates in the form of small globules, which have at first a milky aspect, but which by their union form a transparent liquid. It is purified by repeated washings with water.

This ether does not redden litmus; its smell is strong, and analogous to that of the rest. Its sp. gr. is 1.9206 at 72° F. It assumes in the course of a few days a rose colour, which becomes no deeper by time, and which mercury and potash instantly remove, by seizing the iodine which occasions it.

Hydriodic ether boils at 160° F. At ordinary temperatures, it does not kindle by the approach of a lighted taper to its surface, but only exhales purple vapours, when poured drop by drop on burning coals. Potassium keeps in it, without alteration. Potash does not instantaneously change it. The same may be said of nitric and sulphurous acids, as well as chlorine. By passing it through an incandescent tube, it is converted into a carburetted inflammable gas; into dark brown hydriodic acid; into charcoal; and *flocculi*, whose odour is ethereous, and which M. Gay Lussac considers as a sort of ether, formed of hydriodic acid, and of a vegetable product different from alcohol. These flakes melt in boiling water, and assume on cooling the transparency and colour of wax. They are much less volatile than hydriodic ether, and evolve much more iodine when projected on glowing coals.

Ethers from vegetable acids. Almost all the vegetable acids dissolve in alcohol, and separate from it again by distillation, without any peculiar product being formed, however frequently we act upon the same quantity of acid and alcohol. Such is the case at least with the tartaric, citric, malic, benzoic, oxalic, and gallic acid. But this cannot be said of the acetic. The action of this acid on alcohol is such, that by means of repeated distillations, the two bodies disappear, and form a true ether; whence it has been inferred by M. Thenard, that this fluid is probably the only one of the vegetable acids at present known, which can exhibit by itself the phenomena of etherization. But if instead of putting the vegetable acids alone in contact with alcohol, we add to the mixture one of the concentrated mineral acids, we can then produce with several of them compounds analogous to the preceding ethers. The mineral acid probably acts here by condensing the alcohol, and elevating the temperature, to such a degree as to determine the requisite chemical reaction.

Acetic ether was discovered by Scheele, but first accurately examined by M. Thenard.

Take 100 parts of rectified alcohol, 63 parts of concentrated acetic acid, 17 parts of sulphuric acid of commerce. After having mixed the whole, introduce them into a tubulated glass retort, connected with a large globular receiver surrounded with cold water. On applying heat, the liquid enters into ebullition; and when 123 parts of ether have passed over, the process may be stopped. To render it perfectly pure, we have only to place it, for half an hour, in contact with 10 or 12 parts of the caustic potash of the apothecary, in a corked phial, and to agitate from time to time. Two strata will form; the undermost thin, composed of potash and acetate of potash dissolved in water; the uppermost much more considerable, consisting of pure ether, which may be separated by a long-necked funnel. The sulphuric acid does not enter at all into the composition of this ether. It merely favours the reaction of the alcohol and acetic acid. This mode is much better than the old one, of distilling many times over the same mixture of acetic acid and alcohol. Or we may obtain an excellent acetic ether, very economically, by taking 3 parts of acetate of potash, 3 of concentrated alcohol, and 2 of oil of vitriol; introducing the mixture into a tubulated retort, and distilling to perfect dryness; then mixing the product with the fifth part of its weight of oil of vitriol, and, by a careful distillation, drawing off as much ether as there was alcohol employed.

Acetic ether is a colourless liquid, having an agreeable odour of sulphuric ether and acetic acid. It does not redden litmus paper, or tincture of turnsole. Its taste is peculiar. Its sp. gr. is 0.866, at 44.6° F.

Under the ordinary atmospheric pressure, it enters into ebullition at 160° Fahr. A lighted taper brought near its surface at ordinary temperatures sets fire to it, and it burns with a yellowish-white flame. Acetic acid is developed in the combustion. It is not changed by keeping. Water at 62° dissolves 7½ parts of its weight. When thus dissolved in water, it exercises no action on litmus, and it preserves its characteristic odour and taste. But when this solution is put in contact with the half of its weight of caustic potash, its odour and taste disappear. It is now completely decomposed. Hence, if we submit this liquid to distillation, alcohol passes over, and acetate of potash remains. Acetic ether is, like all the others, very soluble in alcohol, and separable from alcohol by water. Its other properties are unknown. It is used only in medicine, as an exhilarant and diuretic.

Benzoic ether. The presence of a mineral acid is indispensable to its formation, as well as that of the remaining vegetable ethers.

Take 30 parts of benzoic acid, 60 of alcohol, 15 of strong muriatic acid. Introduce these ingredients mixed together into a tubulated retort, and distil into a refrigerated receiver, stopping the operation when two-thirds have passed over. Atmospherical air, and traces of muriatic acid, are the only gaseous products. The first portion of the liquid is alcohol charged with a little acid, but the last will contain a certain quantity of benzoic ether, which is easily separable by water. A larger quantity of this ether remains in the retort, covered by a pretty thick stratum, consisting of alcohol, water, muriatic and benzoic acids. By repeated affusions of hot water into the retort, this stratum will be finally dissolved. It is easy thus to procure benzoic ether. But as so made, it is always contaminated with a portion of benzoic acid, which renders it solid at ordinary temperatures, and makes it act on litmus. It may be purified by agitation with a small quantity of alkaline solution, and subsequent washing with water. There is no muriatic acid found in this purified ether.

Ethers from oxalic acid, citric, &c. When we make a solution of 30 parts of oxalic acid in 35 parts of pure alcohol, and having added 10 parts of oil of vitriol, we subject the whole to distillation till a little sulphuric ether begins to be formed, we shall find that nothing but alcohol slightly etherized has passed into the receiver, and there remains in the retort a brown-coloured strongly acid liquor, from which, on cooling, crystals of oxalic acid fall down. But when we dilute the residual liquor with water, a matter is separated similar to what the benzoic acid yielded, scarcely soluble in water, very abundant, and which is obtained pure by washing it with cold water, and removing, by a little alkali, the excess of acid which it retains.

If we treat in the same way the citric and malic acids, we obtain similar products. The three substances resulting from these three acids have analogous properties. They are all yellowish, somewhat heavier than water, void of smell, perceptibly soluble in water, and very soluble in alcohol, from which they are precipitated by water. They differ from each other in taste. That made from oxalic acid is faintly astringent; that from the citric acid is very bitter. The first is the only one which is volatile; it is vaporized with boiling water, and by this means it is easily obtained white. When heated with a solution of caustic potash, they are all three decomposed, and yield alcohol, along with their peculiar acids; but no trace of sulphuric acid.

Tartaric acid is also susceptible of combining with alcohol like the preceding acids. But it presents some curious phenomena. The experiment, of its formation, must be conducted in the same way as with oxalic acid. We must employ 30 parts of tartaric acid, 35 of alcohol, 10 of oil of vitriol, and distil the mixture till a little sulphuric ether begins to be formed. If at this period we withdraw the heat from the retort, the liquor will assume a syrupy consistence by cooling. But in vain shall we pour in water, in hope of separating, as in the preceding cases, a peculiar combination of the vegetable acid and alcohol. But let us add by degrees solution of potash, we shall throw down much cream of tartar; then, after having just saturated the redundant acid, if we evaporate the liquid, and treat it in the cold with very pure alcohol, we shall obtain, by evaporation of the alcoholic solution, a substance which, on cooling, will become more syrupy than the matter was, before being treated with potash and alcohol. This substance, which is easily prepared in considerable quantity, has a brown colour, and a very bitter and slightly nauseous taste. It is void of smell and acidity, and is very soluble in water and alcohol. It does not precipitate muriate of lime, but copiously the muriate of barytes. When calcined it diffuses dense fumes, which have the odour of garlic, and at the same time it leaves a charcoaly residue, not alkaline, containing much sulphate of potash. Finally, if distilled with potash, it is resolved into a very strong alcohol, and much tartrate of potash. This substance is therefore a combination analogous to the preceding. But what is peculiar to it is its syrupy state, and the property it possesses of rendering soluble in the most concentrated alcohol the sulphate of potash, which of itself is insoluble in ardent spirits. It is perhaps owing to this admixture of sulphate of potash, that it wants the oily aspect belonging to all the other combinations of this genus.

These vegetable-acid ethers may be considered either as compounds of acid and alcohol, or of the ultimate constituents of the former with those of the latter.

Phosphoric and arsenic ethers are made from phosphoric and arsenic acids, and alcohol. They differ in no respect from sulphuric ether. *Boullay*, *Journal de Pharm.* tom. i., and *Lassaigne*, *Ann. de Chim. et de Phys.* tom. xiii, 294.

ETHIOPS (MARTIAL). Black oxide of iron.

ETHIOPS (MINERAL). The black sulphuret of mercury.

ETHIOPS PER SE. Black oxide of mercury, formed by agitation with access of air. The term is obsolete.

EVAPORATION. A chemical operation usually performed by applying heat to any compound substance, in order to separate the volatile parts. It differs from distillation in its object, which chiefly consists in preserving the more fixed matters, while the volatile substances are dissipated and lost. And the vessels are accordingly different; evaporation being commonly made in open shallow vessels, and distillation in an apparatus nearly closed from the external air.

The degree of heat must be duly regulated in evaporation. When the fixed and more volatile matters do not greatly differ in their tendency to fly off, the heat must be very carefully adjusted; but in other cases this is less necessary.

As evaporation consists in the assumption of the elastic form, its rapidity will be in proportion to the degree of heat, and the diminution of the pressure of the atmosphere. A current of air is likewise of service in this process.

In treating of alum, I alluded to a method of evaporating liquors lately introduced into large manufactories. A water-tight stone cistern, about three or four feet broad, two feet deep, and 20, 30, or 40 feet long, is covered above by a low brick arch. At one extremity of this tunnel a grate is built, and at the other a lofty chimney. When the cistern is filled, and a strong fire kindled in the reverberatory grate, the flame and hot air sweep along the surface of the liquor, raise the temperature of the uppermost stratum, almost instantly, to near the boiling point, and draw it off in vapour. The great extent, rapidity, and economy of this process, recommend it to general adoption on the large scale.

Mr. Barry has lately obtained a patent for an apparatus, by which vegetable extracts for the apothecary may be made at a very gentle heat, and *in vacuo*. From these two circumstances, extracts thus prepared differ from those in common use, not only in their physical, but medicinal properties. The taste and smell of the extract of hemlock made in this way are remarkably different, as is the colour both of the soluble and feculent parts. The form of apparatus is as follows:—

The evaporating pan, or still, is a hemispherical dish of cast-iron, polished on its inner surface, and furnished with an air-tight flat lid. From the centre of this a pipe rises, and bending like the neck of a retort, it forms a declining tube, which terminates in a copper sphere of a capacity three (four?) times greater than that of the still. There is a stop-cock on that pipe, midway between the still and the globe, and another at the under side of the latter.

The manner of setting it to work is this:—The juice, or infusion, is introduced through a large opening into the polished iron still, which is then closed, made air-tight, and covered with water. The stop-cock which leads to the sphere, is also shut. In order to produce the vacuum, steam, from a separate apparatus, is made to rush by a pipe through the sphere, till it has expelled all the air, for which five minutes are commonly sufficient. This is known to be effected, by the steam issuing uncondensed. At that instant the copper sphere is closed, the steam shut off, and cold water admitted on its external surface. The vacuum thus produced in the copper sphere, which contains four-fifths of the air of the whole apparatus, is now partially transferred to the still, by opening the intermediate stop-cock. Thus, four-fifths of the air in the still rush into the sphere, and the stop-cock being shut again, a second exhaustion is effected by steam in the same manner as the first was; after which, a momentary communication is again allowed between the iron still and the receiver; by this means, four-fifths of the air remaining after the former exhaustion, are expelled. These exhaustions, repeated five or six times, are usually found sufficient to raise the mercurial column to the height of 28 inches. The water bath, in which the iron still is immersed, is now to be heated, until the fluid that is to be inspissated begins to boil, which is known by inspection through a window in the apparatus, made by fastening on, air-tight, a piece of very strong glass; and the temperature at which the boiling point is kept up, is determined by a thermometer. *Ebullition* is continued until the fluid is inspissated to the proper degree of consistence, which also is tolerably judged of by its appearance through the glass window. The temperature of the boiling fluid is usually about 100° F., but it might be reduced to nearly 90°.

In the autumn of 1821, Mr. Barry showed M. Clement and myself the details of his evaporatory apparatus, with the ingenuity and performance of which we were highly satisfied. Learning since that he had made some further improvements, I solicited him to favour me with a description and drawing of its present form, for insertion in the second edition of this Dictionary; with which request he politely complied.

In the Medico-Chirurgical Transactions for 1819, (vol. x.) there is a paper by J. T. Barry on a new method of preparing Pharmaceutical Extracts. It consists in performing the evaporation *in vacuo*. For this purpose he employed apparatus which was found to answer so well, that, contemplating its application to other manufactures, he was induced to take out a patent for it, that is to say, *for the apparatus*. As it has been erroneously supposed that the patent is for preparing extracts *in vacuo*, it may not be improper to correct the statement by a short quotation from the above paper. "On that account, I have been induced to take out a patent for it, (the apparatus). It is, however, to be recollected by this society, that I have declined having a patent for its pharmaceutical products. Chemists, desirous of inspissating extracts *in vacuo*, are therefore at liberty to do it in any apparatus differing from that which has been made the subject of my patent; and thus these substances may continue the object of fair competition as to quality and price."

The apparatus combines two striking improvements. The first consists in producing a vacuum by the agency of *steam only*, so that the use of air-pumps and the machinery requisite for working them, is superseded. This is effected on the same principle as in the steam-engine, the filling of a given space with steam, and then condensing it. By a subsequent improvement, the two operations of heating and cooling are carried on at once, by means of two cylinders. The movement of a sliding valve, which serves to open and shut the respective passages, causes these exhausting cylinders to alternately communicate with the apparatus, and quickly produce the vacuum; when the steam, being no longer required for the same purpose, is employed as the heating medium.

The other improvement is a contrivance for superseding the injection of water during the process of evaporation *in vacuo*. Injection has some serious disadvantages; it introduces air, and quickly fills up the exhausted vessels with water. Hence it is necessary to keep pumps constantly in action, and this cannot be done without an enormous expenditure of power, because they are counteracted by the atmospheric pressure. The method recommended by J. T. Barry, devoid of these inconveniencies, effects quite as speedily the condensation of vapour, by cold externally applied to a part denominated *the refrigerator*, which stands immersed in water. He directs a thin sheet of metal to be indented all over at suitable distances, so as to produce on its opposite surface regular series of convexities. It is then laid on a sheet of the same size, and the two being in contact at the summits of the convexities, are approximated and soldered together at the edges of the sheets all round, reserving an aperture at the upper part for the admission of vapour, and another at the lowest point for its escape when reduced to fluid. This description of the refrigerator will be understood on reference to Plate X. fig. 2; but the specification of the patent describes various other methods of effecting the same object, taking for its principle, the "letting the two sides of the refrigerator rest against each other at numerous parts, (either immediately, or by the medium of one or more interposed bodies), so that they shall *not collapse entirely* when the refrigerator is exhausted of air."

Having given a particular description of the refrigerator, and the mode of exhausting the apparatus, a few words will suffice to explain the other parts. Plate VII. fig. 1. shows one of the evaporating vessels A, with its cistern B, and refrigerating plates. The cistern is kept cool after the manner of a distiller's worm-tub. The evaporating vessel is furnished with several appendages, such as, the charging measure *c*, and discharging pipe *d*, which is moved perpendicularly by its lever; man-hole *g*, and chamber *f*, for catching any fluid that may chance to boil over: it is surrounded at the lower part with a steam-case *e*, for boiling its contents. There is also a vacuum-gauge, &c. not delineated in the section. Thus far the arrangement does not differ materially from that adopted by the sugar-refiners manufacturing under Howard's patent.

A pipe *m*, passing from the chamber *f*, into the cistern, gives origin to several refrigerating plates, (seven in the present instance), which have their lower extremities terminating in another pipe *n*. The transverse section in fig. 1. exhibits these plates upright and parallel with each other in the cold water cistern; they occupy very little room, and may therefore be multiplied to an indefinite number, to furnish a proportionate quantity of cooling surface. On entering these, the vapour is instantly condensed, and dropping into the lower pipe, is conducted to a *cylindrical* receiver, shown by the transverse section *h*. It is of sufficient capacity to collect all the fluid condensed during the process.

Fig. 3. represents a series of evaporators (drawn to half the scale of fig. 1.) as arranged for a sugar-house. It will be observed, that one long cistern serves for the whole, and it may be situated outside the walls of the building. A single pair of exhausting steam-cylinders, (which, being under the cistern, are not seen in the sketch), answers for any number of evaporators, having with each a separate connexion, that is shut or opened at pleasure by a sliding valve.

We shall conclude the account of this invention with Mr. Barry's summary remarks, inserted in the Repertory of Arts at the time the editors of that work published the specification.

"The apparatus described in the preceding specification is applicable to some manufactures, where the substances operated upon suffer injury in the process of boiling, but especially to sugar; and it is particularly worthy the notice of those sugar-refiners who may be likely to adopt the use of Howard's patents, as it will afford them some very important advantages.

"These advantages principally consist in,

"First, The *small cost of the apparatus*; no *air-pumps* or other machinery being necessary.

"Secondly, The saving of *large annual expenses*, hitherto incurred for *supplying power* to work the heavy machinery attached to the pumps.

"Thirdly, Expensive repairs avoided, as a consequence.

"Fourthly, Danger of derangement and suspension of work avoided, as another consequence.

"Fifthly, A large *saving of water*, by the use of a peculiar refrigerator, which constitutes one of the improvements of this patent.

"Sixthly, The *facility* with which the *vacuum is obtained*; the operation being completed in less than five minutes, and requiring no repetition: And the *perfection of the vacuum*; the patentee in his experiments having boiled syrup at even lower temperatures than are provided for in the scale adopted by Howard."

In the sixth volume of the Annals of Philosophy, Dr. Prout has described an ingenious apparatus, by means of which he can subject substances, which he wishes thoroughly to dry, to the influence of a gentle heat, conjoined with the desiccating power of sulphuric acid on bodies placed *in vacuo*. See Congelation.

From M. Biot's report, it seems to have been ascertained in some French manufactories, that evaporation goes on more rapidly from a liquid boiling in a covered vessel, from the top of which a pipe issues, than when the liquid is freely exposed to the air; the fuel or heat applied, and extent of surface, being the same in both cases.

EUCHLORINE. Protoxide of chlorine.

EUCLASE. Prismatic Emerald.

EUDIALITE. A mineral belonging to the tessular system of Mohs. Cleavage, octohedral. Brownish-red colour. Sp. gr. 2.8 to 3.0.—*Stromeyer.*

EUDIOMETER. An instrument for ascertaining the purity of air, or rather the quantity of oxygen contained in any given bulk of elastic fluid. Dr. Priestley's discovery of the great readiness with which nitrous gas combines with oxygen, and is precipitated in the form of nitric acid,—see Acid (Nitric),—was the basis upon which he constructed the first instrument of this kind.

His method was very simple: a glass vessel, containing an ounce by measure, was filled with the air to be examined, which was transferred from it to a jar of an inch and a half diameter inverted in water; an equal measure of fresh nitrous gas was added to it; and the mixture was allowed to stand two minutes. If the absorption were very considerable, more nitrous gas was added, till all the oxygen appeared to be absorbed. The residual gas was then transferred into a glass tube two feet long, and one-third of an inch wide, graduated to tenths and hundredths of an ounce measure; and thus the quantity of oxygen absorbed was measured by the diminution that had taken place.

Von Humboldt proposes that the nitrous gas should be examined, before it is used, by agitating a given quantity with a solution of sulphate of iron.

Sir H. Davy employs the nitrous gas in a different manner. He passes it into a saturated solution of green muriate or sulphate of iron, which becomes opaque, and almost black, when fully impregnated with the gas. The air to be tried is contained in a small graduated tube, largest at the open end, which is introduced into the solution, and then gently inclined toward the horizon, to accelerate the action, which will be complete in a few minutes, so as to have absorbed all the oxygen. He observes, that the measure must be taken as soon as this is done, otherwise the bulk of the air will be increased by a slow decomposition of the nitric aid formed.

Volta had recourse to the accension of hydrogen gas. For this purpose, two measures of hydrogen are introduced into a graduated tube, with three of the air to be examined, and fired by the electric spark. The diminution of bulk, observed after the vessel had returned to its original temperature, divided by three, gives the quantity of oxygen consumed.

Phosphorus and sulphuret of potash have likewise been employed in eudiometry.

A piece of phosphorus may be introduced by means of a glass rod into a tube containing the air to be examined standing over water, and suffered to remain till it has absorbed its oxygen; which, however, is a slow process. Or a glass tube may be filled with mercury and inverted, and a piece of phosphorus, dried with blotting paper, introduced, which will of course rise to the top. It is there to be melted, by bringing a red-hot iron near the glass, and the air to be admitted by little at a time. At each addition the phosphorus inflames; and, when the whole has been admitted, the red-hot iron may be applied again, to ensure the absorption of all the oxygen. In either of these modes 1-40th of the residuum is to be deducted, for the expansion of the nitrogen, by means of a little phosphorus which it affords.

Professor Hope of Edinburgh employs a very convenient eudiometer, when sulphuret of potash or Sir H. Davy's *liquid* is used. It consists of two glass vessels, one to hold the solution of sulphuret of potash, or other eudiometric liquor, about two inches in diameter, and three inches high, with a neck at the top as usual, and a tubulure, to be closed with a stopple in the side near the bottom: the other is a tube, about eight inches and a half long, with a neck ground to fit into that of the former. This being filled with the air to be examined, and its mouth covered with a flat piece of glass, is to be introduced under water, and there inserted into the mouth of the bottle. Taking them out of the water, and inclining them on one side, they are to be well shaken, occasionally loosening the stopper in a basin filled with water, so as to admit this fluid to occupy the vacuum occasioned by the absorption. Bottles of much smaller size than here mentioned, which is calculated for public exhibition, may generally be employed; and, perhaps, a graduated tube, ground to fit into the neck of a small phial, without projecting within it, may be preferable on many occasions, loosening it a little under water, from time to time, as the absorption goes on.

Mr. Dalton has written largely on the nitrous gas eudiometer. He says, that 21 measures of oxygen can unite with 36 measures, or twice 36 = 72 measures of nitrous gas; that is, 100 with 171.4 or 342·8. Phil. Mag. vol. xxiii. and Manch. Mem. new series, 1.

M. Gay Lussac, in his excellent memoir on nitrous vapour and nitrous gas, has proved, that no confidence can be reposed in the directions of Mr. Dalton for analyzing gases. Nitrous gas is there fully demonstrated to be a compound of equal volumes of oxygen and azote, and the apparent contraction of their volume is null; for 100 of the one and 100 of the other produce exactly 200 of nitrous gas. *Nitric* acid is composed of 100 parts of azote, and 200 of oxygen, or of 100 oxygen and 200 nitrous gas; = (100 o. + 100 az.). Nitrous vapour, or, more accurately speaking, *nitrous* acid gas, results from the combination of 100 of oxygen with 300 of nitrous gas. Hence, by giving predominance alternately to the oxygen and to the nitrous gas, we obtain 300 of absorption and *nitric* acid, or 400 of absorption and *nitrous* acid. The nitrous acid gas is an identical compound, very soluble in water, which it colours at first blue, then green, and lastly, orange-yellow. This liquid, with the alkalis, forms nitrites. These clear and simple facts constitute the whole theory of the formation of the nitrous and nitric acids, by means of nitrous gas and oxygen, and perfectly explain the differences of the results of all those who have operated with them. We have now only to show, how we may render the use of nitrous gas perfectly accurate in eudiometry.

It is stated above, that we obtain nitric acid and an absorption represented by three, or nitrous acid and a diminution of volume represented by four, every time, according as the oxygen or nitrous gas predominates in the mixture of these two gases. Now, since the object is to withdraw the whole oxygen from air, we must add the nitrous gas in excess to it, and cause thus a diminution of volume four times greater than the volume of the contained oxygen. Notwithstanding this precaution, if we make the mixture in a very narrow tube, the nitrous vapour would be absorbed with difficulty by the water, on account of the narrow contact, and agitation would become necessary. But in this case, nitrous gas, to the amount of 10 or 12 per cent. would be absorbed. It is from this cause, that on mixing 100 parts of air with 100 of nitrous gas, very variable absorptions were obtained, of which the mean was 93; whilst air, containing at utmost 21 per cent. of oxygen, the absorption should be only four times this quantity, or 84. Nor is it a matter of indifference, to put the nitrous gas in the tube before, or after the other gas; for if we introduce it first, there might be formed both nitrous and nitric acids. Knowing these two causes of error, it is easy to avoid them, by obeying the following injunctions of M. Gay Lussac.

'Instead of selecting a very narrow tube, as Mr. Dalton prescribed, we must take a very wide tube, a tumbler for example, and after having introduced into it 100 of the air to be examined, we must pass into it 100 parts of the nitrous gas. There is instantly exhibited a red vapour, which disappears very speedily without agitation, and after half a minute, or a minute at most, the absorption may be regarded as complete. We transfer the residuum into a graduated tube, and we shall find the absorption to be almost uniformly 84 parts, provided atmospheric air was used, one-fourth of which = 21, indicates the quantity per cent. of oxygen.

M. Gay Lussac shows, by numerous experiments, the accuracy of the above process, in varied circumstances. We have thus the advantage of estimating the proportion of oxygen in any gas, by an absorption four times greater than its own volume; so that the errors of experiment are reduced to one-fourth, on the quantity of oxygen. Now, as we can never commit a mistake of four degrees, the error must be less than one per cent. We must never agitate, or use an under proportion of nitrous gas, nor yet carry its excess too far, on account of its solubility in water.

An apparatus for analyzing gases, containing oxygen or chlorine, by explosion with hydrogen, was communicated by me to the Royal Society of Edinburgh, and published in the volume of their Transactions for 1817 and 1818.

Description of an Apparatus for the Analysis of Gaseous Matter by Explosion.

The analysis of combustible gases, and supporters of combustion, reciprocally, by explosion with the electric spark, furnishes, when it can be applied, one of the speediest and most elegant methods of chemical research. The risk of failure to which the chemist is exposed, in operating with the simple tube, from the ejection of the mercury, and escape or introduction of the air; or of injury, from the bursting of the glass, by the forcible expansion of some gaseous mixtures, has given rise to several modifications of apparatus.

Volta's mechanism, which is employed very much at Paris, is complex and expensive *, while it is hardly applicable to experiments over mercury. Mr. Pepys' ingenious contrivance, in which the glass tube is connected with a metallic spring, to diminish the shock of explosion, is liable also to some of the above objections.

A very simple form of instrument occurred to me about two years ago, in which the atmospheric air, the most elastic and economical of all springs, is employed to receive and deaden the recoil. Having frequently used it since that time, I can now recommend it to the chemical world, as possessing every requisite advantage of convenience, cheapness, safety, and precision.

It consists of a glass syphon, having an interior diameter of from 2-10ths to 4-10ths of an inch. Its legs are of nearly equal length, each being from six to nine inches long. The open extremity is slightly funnel-shaped; the other is hermetically sealed; and has inserted near to it, by the blowpipe, two platina wires. The outer end of the one wire is incurvated across, so as nearly to touch the edge of the aperture; that of the other is formed into a little hook, to allow a small spherical button to be attached to it, when the electrical spark is to be transmitted. The two legs of the glass syphon are from one-fourth to one-half inch asunder.

The sealed leg is graduated, by introducing successively equal weights of mercury from a measure glass tube. Seven ounces troy and 66 grains occupy the space of a cubic inch; and 34½ grains represent $\frac{1}{100}$ part of that volume. The other leg may be graduated also, though this is not necessary. The instrument is then finished.

To use it, we first fill the whole syphon with mercury or water, which a little practice will render easy. We then introduce into the open leg, plunged into a pneumatic trough, any convenient quantity of the gases, from a glass measure tube, containing them previously mixed in determinate proportions. Applying a finger to the orifice, we next remove it from the trough in which it stands, like a simple tube; and by a little dexterity, we transfer the gas into the sealed leg of the syphon. When we conceive enough to have been passed up, we remove the finger, and next bring the mercury to a level in both legs, either by the addition of a few drops, or by the displacement of a portion, by thrusting down into it a small cylinder of wood. We now ascertain, by careful inspection, the volume of included gas. Applying the forefinger again to the orifice, so as also to touch the end of the platina wire, we then approach the pendent ball or button to the electrical machine, and transmit the spark. Even when the included gas is considerable in quantity, and of a strongly explosive power, we feel at the instant nothing but a slight push or pressure on the tip of the finger. After explosion, when condensation of volume ensues, the finger will feel pressed down to the orifice by the superincumbent atmosphere. On gradually sliding the finger to one side, and admitting the air, the mercurial column in the sealed leg will rise more or less above that in the other. We then pour in this liquid metal, till the equilibrium be again restored, when we read off as before, without any reduction, the true resulting volume of gas.

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* The price of the apparatus is three guineas.

As we ought always to leave two inches or more of air, between the finger and the mercury, this atmospheric column serves as a perfect recoil spring, enabling us to explode very large quantities without any inconvenience or danger. The manipulation is also, after a little practice, as easy as that of the single tube. But a peculiar advantage of this detachable instrument is, to enable us to keep our pneumatic troughs, and electrical machine, at any distance which convenience may require; even in different chambers, which, in the case of wet weather, or a damp apartment, may be found necessary to ensure electrical excitation. In the immediate vicinity of the water pneumatic cistern, we know how often the electric spark refuses to issue from a good electrophorus, or even little machine. Besides, no discharging rod or communicating wire is here required. Holding the eudiometer in the left hand, we turn the handle of the machine, or lift the electrophorus plate with the right, and approaching the little ball, the explosion ensues. The electrician is well aware, that a spark so small as to excite no unpleasant feeling in the finger, is capable, when drawn off by a smooth ball, of inflaming combustible gas. Even this trifling circumstance may be obviated, by hanging on a slender wire, instead of applying the finger.

We may analyze the residual gaseous matter, by introducing either a liquid or a solid reagent. We first fill the open leg nearly to the brim with quicksilver, and then place over it the substance whose action on the gas we wish to try. If liquid, it may be passed round into the sealed leg among the gas; but if solid, fused potash, for example, the gas must be brought round into the open leg, its orifice having been previously closed with a cork or stopper. After a proper interval, the gas being transferred back into the graduated tube, the change of its volume may be accurately determined. With this eudiometer, and a small mercurial pneumatic cistern, we may perform pneumatic analyses on a very considerable scale.

It may be desirable in some cases to have ready access to the graduated leg, in order to dry it speedily. This advantage is obtained by closing the end of the syphon, not hermetically, but with a little brass cap screwed on, traversed vertically by a platina wire insulated in a bit of thermometer tube. After the apparatus has been charged with gas for explosion, we connect the spherical button with the top of the wire.

With the above instrument I have exploded half a cubic inch of hydrogen mixed with a quarter of a cubic inch of oxygen; as also, a bulk nearly equal of an olefiant gas explosive mixture, without any unpleasant concussion or noise; so completely does the air-chamber abate the expansive violence, as well as the loudness of the report. Projection of the mercury, or displacement of the gas, is obviously impossible. *Edin. Phil. Trans. Jan.* 1818.

Dobereiner has suggested the use of a pellet of spongy platinum for the purpose of detecting minute portions of oxygen in a gaseous mixture, in which hydrogen also is present. Its effect is immediate. The moment the substance rises above the surface of the mercury in the tube containing the mixture, the combination of the oxygen and hydrogen begins, and in a few minutes is completed. It seems capable of indicating the smallest quantity of oxygen. The spongy platinum, for this purpose, is usually made up into a pellet of the size of a pea, with a little precipitated alumina, and then ignited at the blowpipe, immediately before using it. No error need be apprehended from the formation of ammonia in the analysis of atmospheric air in this way. Dobereiner says, that the spongy platinum is so energetic an agent, that it enables hydrogen to take 1 of oxygen from 99 of azote, a result not to be hoped for by explosion with electricity. A platinum pellet, made up with potter's clay, and weighing from 2 to 6 grains, may be employed above a thousand times, if dried carefully after each operation. The compound gases containing hydrogen do not combine with oxygen, through the agency of the platinum. Dr. Henry has ingeniously applied Dobereiner's invention, to the analysis of mixtures of inflammable gases, such as are evolved from coal. *Phil. Trans.* 1824, *Part* 2. See HYDROGEN.

EUDYALITE. This mineral occurs both massive and crystallized. Colour red, or brownish-red. It consists of silica 53.325; zirconia 11.102; lime 9.735; soda 13.822; oxide of iron 7.754; oxide of manganese 2.062; muriatic acid 1.034; water 1.801. It readily dissolves in acids. It accompanies the sodalite of Greenland. *Phillips' Mineralogy.*

EUKAIRITE. A new mineral found in the copper mine of Skrickerum, in the parish of Tryserum, in Smoland. Berzelius found it to consist of 38.93 silver, 26 selenium, 23 copper, and 8.9 alumina. There was a loss of 3 per cent. He regards it as a compound of 2 atoms of seleniuret of copper, and 1 atom of bi-seleniuret of silver. Its colour is lead-blue; lustre metallic; texture granular, with a crystallized aspect. Soft; sectile; somewhat malleable. It melts before the blowpipe, exhaling a strong smell of horse-radish, and leaving a metallic button.

EUPHORBIUM. A gum-resin exuding from a large oriental shrub, Euphorbia officin. Linn.

It is brought to us immediately from Barbary, in drops of an irregular form; some of which upon being broken are found to contain little thorns, small twigs, flowers, and other vegetable matters; others are hollow, without any thing in their cavity: the tears in general are of a pale yellow colour externally, somewhat white withinside: they easily break betwixt the fingers. Sp. gr. 1.124. Slightly applied to the tongue, they affect it with a very sharp biting taste; and, upon being held for some time in the mouth, prove vehemently acrimonious, inflaming and exulcerating the fauces, &c. Euphorbium is extremely troublesome to pulverize, the finer part of the powder, which flies off, affecting the head in a violent manner. The acrimony is so great, as to render it absolutely unfit for any internal use. It is much employed in the veterinary art as an epispastic:—

The following constituents were found in euphorbium by Braconnot:—

Resin,	37.0
Wax,	19.0
Malate of lime,	20.5
Malate of potash,	2.0
Water,	5.0
Woody matter,	13.5
Loss,	3.0
	100.0

The resin is excessively acrid, poisonous, reddish-coloured, and transparent. It dissolves in sulphuric and nitric acid, but not in alkalis, in which respect it differs from other resins. Euphorbium itself is pretty soluble in alcohol.

EUPHOTIDE. A rock species of M. de Buch, essentially composed of felspar and diallage. The Italian artists call it *gabbro*. M. Haüy gave it the name euphotide. The felspar is found in it frequently, under the form of *jade*, a substance which M. de Buch thinks ought to be separated from common felspar. The second mineral presents itself in all its varieties. Independently of these composing principles, there is accidentally found in it, talc, amphibole, or actinote, garnets, grains of pyrites, &c. This rock is abundant in the Alps. It is found in great quantity among the rounded pebbles in the neighbourhood of Geneva. M. de Buch met with it on the elevated portions of Monte Rosa, forming considerable masses, supraposited on the micaceous schist, and mixed in several places with serpentine. The tops of the mountains of the territory of Genoa, which overlook the Gulf of Spezzia, are composed principally of it. It forms also in Corsica districts of a pretty considerable extent, whence is derived the *verde di Corsica*, a fine variety of this rock. The *nero di prato*, the *verde di prato*, the *granito di gabbro* of the Florentines, are merely diallages, habitually metalloid, and mixed sometimes with serpentine, sometimes with felspar or jade, which are brought from the mountains of Tuscany. *D'Aubuisson.*

EXCREMENTS. The constituents of human feces, according to the recent analysis of Berzelius, are the following:—

Water,	73·3
Vegetable and animal remains,	7·0
Bile,	0·9
Albumen,	0·9
Peculiar extractive matter,	2·7
Salts,	1·2
Slimy matter, consisting of picromel, peculiar animal matter, and insoluble residue,	14·0
	100·0

The salts were to one another in the following proportions:—

Carbonate of soda,	0·9
Muriate of soda,	0·1
Sulphate of soda,	0·05
Ammon. phos. magn.	0.05
Phosphate of lime,	0·1
	1·20

Thaer and Einhof obtained, by ignition, from 3840 grains of the excrements of cattle, fed at the stall chiefly on turnips, the following earths and salts:—

Lime,	12
Phosphate of lime,	12·5
Magnesia,	2·0
Iron	5·0
Alumina with some manganese,	14·0
Silica,	52·0
Muriate and sulphate of potash,	1·2
	98·7

To MM. Fourcroy and Vauquelin we owe what precise knowledge we possess regarding the excrements of birds, in which they found a large quantity of uric acid. This forms the white, and nearly crystalline portion. It does not proceed from the fæcal matter peoperly so called, but from the urine, which in this class of animals is mixed with the excrement, by the nature of their organization. This acid is easily extracted, by breaking the excrement with alkaline water, filtering the liquor, and pouring into it muriatic acid. For the value of this fæcal matter in agriculture, see MANURE.

The excrements of the serpent, *Boa Constrictor*, consist, according to Dr. Prout, of urate of ammonia, to the amount of fully nine-tenths of their weight.

EXPANSION. See Caloric.

EXTRACT. When decoction is carried to such a point as to afford a substance either solid or of the consistence of paste, this residual product is called an extract. When chemists speak of extract, they most commonly mean the product of aqueous decoction; but the earlier chemists frequently speak of spirituous extract.

Extracts thus prepared are mixtures of several of the materials of vegetables, whence they differ greatly, according to the plants from which they are obtained; but modern chemists distinguish by the name of extract, or *extractive matter*, a peculiar substance, supposed to be one of the immediate materials of vegetables, and the same in all, when separated from any foreign admixture, except as the proportion of its constituent principles may vary. See Evaporation.

EXTRACTIVE. The name given to a supposed product of vegetation, present in the juices of plants. Its identity is very doubtful. It is said to have a bitter taste, a deep brown colour, brittle, with a shining fracture when it is dried; to yield on distillation an acid and ammoniacal liquor; to be soluble in water and alcohol; to combine with the greater part of metallic oxides; and, lastly, to combine with oxygen and become insoluble in water; a result which happens when it is treated with oxygenated acids, or dissolved in water and evaporated a great number of times. I join M. Thenard in doubting its existence as a distinct product.

EYE. The humours of the eye had never been examined with any degree of accuracy till lately by M. Chenevix. Most of his experiments were made with the eyes of sheep, as fresh as they could be procured.

The aqueous humour is a clear, transparent liquid, with little smell or taste, and of the temperature of 60°; its specific gravity is 1·009. It consists of water, albumen, gelatine, and muriate of soda.

The crystalline contains a much larger proportion of water, and no muriate. Its specific gravity is 1·1.

The vitreous humour, when pressed through a rag to free it from its capsules, differed in nothing from the aqueous, either in its specific gravity or chemical nature.

Fourcroy mentions a phosphate as contained in these humours; but M. Chenevix could discover none.

The humours of the human eye gave the same products, but the specific gravity of the crystalline was only 1·079, and that of the aqueous and vitreous humours 1·0053.

The eyes of oxen differed only in the specific gravity of the parts, that of the crystalline being 1·0765, and that of the other humours 1·0088.

The specific gravity of the crystalline is not equal throughout, its density increasing from the surface to the centre.—*Phil. Trans.* 1803.

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FAHLUNITE. *Automalite*, a sub-species of octohedral corundum.

FARINA. Vegetable flour.

The flour of the Parisian bakers consists, according to M. Vauquelin, of gluten 10·2, starch 72·8, sweet matter 4·2, gummi-glutinous matter 2·8, and moisture 10 in 100 parts. *Journ. de Pharm. August*, 1822.

FAT. Concerning the nature of this important product of animalization, nothing definite was known till M. Chevreul devoted himself with meritorious zeal and perseverance to its investigation. He has already published in the Annales de Chimie, seven successive memoirs on the subject, each of them surpassing its predecessor in interest. We shall in this article give a brief abstract of the whole.

By dissolving fat in a large quantity of alcohol, and observing the manner in which its different portions were acted upon by this substance, and again separated from it, it is concluded that fat is composed of an *oily substance*, which remains fluid at the ordinary temperature of the atmosphere; and of another *fatty substance* which is much less fusible. Hence it follows, that fat is not to be regarded as a simple principle, but as a combination of the above two principles, which may be separated without alteration. One of these substances melts at about 45°, the other at 100°; the same quantity of alcohol which dissolves 3·2 parts of the *oily substance*, dissolves 1·8 only of the *fatty substance*: the first is separated from the alcohol in the form of an oil; the second in that of small silky needles. See Elain.

Each of the constituents of natural fat was then saponified by the addition of potash; and an accurate description given of the compounds which were formed, and of the proportions of their constituents. The *oily substance* became saponified more readily than the *fatty substance*; the residual fluids in both cases contained the sweet oily principle; but the quantity that proceeded from the soap formed of the *oily substance*, was four or five times as much as that from the *fatty substance*. The latter soap was found to contain a much greater proportion of the *pearly matter* than the former, in the proportion of 7·5 to 2·9; the proportion of the *fluid fat* was the reverse, a greater quantity of this being found in the soap formed from the oily substance of the fat.

When the principles which constitute fat unite with potash, it is probable that they experience a change in the proportion of their elements. This change developes at least three bodies, *margarine*, *fluid fat*, and *the sweet principle;* and it is remarkable, that it takes place without the absorption of any foreign substance, or the disengagement of any of the elements which are separated from each other. As this change is effected by the intermedium of the alkali, we may conclude that the newly formed principles must have a strong affinity for salifiable bases, and will in many respects resemble the acids; and, in fact, they exhibit the leading characters of acids, in reddening litmus, in decomposing the alkaline carbonates to unite to their bases, and in neutralizing the specific properties of the alkalis.

Having already pointed out the analogy between the properties of acids and the principles into which fat is converted by means of the alkalis, the next object was to examine the action which other bases have upon fat, and to observe the effect of water, and of the cohesive force of the bases upon the process of saponification. The substances which the author subjected to experiment, were soda, the four alkaline earths, alumina, and the oxides of zinc, copper, and lead. After giving a detail of the processes which he employed with these substances respectively, he draws the following general conclusions:—Soda, barytes, strontian, lime, the oxide of zinc, and the protoxide of lead, convert fat into *margarine fluid fat*, *the sweet principle*, *the yellow colouring principle*, and *the odorous principle*, precisely in the same manner as potash. Whatever be the base that has been employed, the products of saponification always exist in the same relative proportion. As the above mentioned bases form with margarine and the fluid fat compounds which are insoluble in water, it follows, that the action of this liquid, as a solvent of soap, is not essential to the process of saponification. It is remarkable that the oxides of zinc and of lead, which are insoluble in water, and which produce compounds equally insoluble, should give the same results with potash and soda,—a circumstance which proves that those oxides have a strong alkaline power. Although the analogy of magnesia to the alkalis is, in other respects, so striking, yet we find that it cannot convert fat into soap under the same circumstances with the oxides of zinc and lead.

It was found that 100 parts of hog's-lard were reduced to the completely saponified state by 16·36 parts of potash. See ELAIN and ACID (MARGARIC).

The properties of spermaceti were next examined: it melts at about 112°: it is not much altered by distillation; it dissolves readily in hot alcohol, but separates as the fluid cools; the solution has no effect in changing the colour of the tincture of litmus, a circumstance, as it is observed, in which it differs from margarine, a substance which, in many respects, it resembles.—Spermaceti is capable of being saponified by potash, with nearly the same phenomena as when we submit hog's lard to the action of potash, although the operation is effected with more difficulty.

The author's general conclusion respecting the fatty matter of dead bodies is, that even after the lactic acid, the lactates, and other ingredients which are less essential, are removed from it, it is not a simple, ammoniacal soap, but a combination of various fatty substances with ammonia, potash, and lime. The fatty substances which were separated from alcohol, had different melting points, and different sensible properties. It follows, from M. Chevreul's experiments, that the substance which is the least fusible, has more affinity for bases than those which are more so. It is observed, that adipocere possesses the characters of a saponified fat; it is soluble in boiling alcohol in all proportions, reddens litmus, and unites readily to potash, not only without losing its weight, but without having its fusibility or other properties changed.

M. Chevreul has shown, that hog's-lard, in its natural state, has not the property of combining with alkalis; but that it acquires it by experiencing some change in the proportion of its elements. This change being induced by the action of the alkali, it follows that the bodies of the new formation must have a decided affinity for the species of body which has determined it. If we apply this foundation of the theory of saponification to the change into fat which bodies buried in the earth experience, we shall find that it explains the process in a very satisfactory manner. In reality, the fatty matter is the combination of the two adipose substances with ammonia, lime, and potash: one of these substances has the same sensible properties with margarine procured from the soap of hog's-lard; the other, the orange-coloured oil, excepting its colour, appears to have a strong analogy with the fluid fat. From these circumstances, it is probable that the formation of the fatty matter may be the result of a proper saponification produced by ammonia, proceeding from the decomposition of the muscle, and by the potash and lime, which proceed from the decomposition of certain salts.

The author remarks, that he has hitherto made use of periphrases when speaking of the different bodies that he has been describing, as supposing that their nature was not sufficiently determined. He now, however, conceives, that he may apply specific names to them, which will both be more commodious, and, at the same time, by being made appropriate, will point out the relation which these bodies bear to each other. The following is the nomenclature which he afterwards adopted:—The crystalline matter of human biliary calculi is named *cholesterine*, from the Greek words χολη, bile, and ϛερεος, solid; spermaceti is named *cetine*, from κητος, a whale; the fatty substance and the oily substance, are named respectively, *stearine*, and *elaïne*, from the words ϛεαρ, fat, and ελαιον, oil; margarine, and the fluid fat obtained after saponification, are named *margaric acid* and *oleic acid*, while the term *cetic acid* is applied to what was named saponified spermaceti. The *margarates*, *oleates*, and *cetates*, will be the generic names of the soaps or combinations which these acids are capable of forming by their union with salifiable bases.

Two portions of human fat were examined, one taken from the kidney, the other from the thigh: after some time they both of them manifested a tendency to separate into two distinct substances, one of a solid, and the other of a fluid consistence: the two portions differed in their fluidity and their melting point. These variations depend upon the different proportions of stearine and elaïne; for the concrete part of fat is a combination of the two with an excess of stearine, and the fluid part is a combination with an excess of elaïne. The fat from the other animals was then examined, principally with respect to their melting point and their solubility in alcohol; the melting point was not always the same in the fat of the same species of animal. When portions of the fat of different sheep are melted separately at the temperature of 122°, in some specimens the thermometer descends to 98.5°, and rises again to 102°: while in others it descends to 104°, and rises again to 106°. A thermometer plunged into the fat of the ox melted at 122°, descended to 98.5°, and rose again to 102°. When the fat of the jaguar was melted at 104°, the thermometer descended to 84°, and rose again to about 85°; but a considerable portion of the fat still remained in a fluid state. With respect to the solubility of the different kinds of fat in alcohol, it was found that 100 parts of it dissolved 2.48 parts of human fat, 2.26 parts of sheep's fat, 2.52 parts of the fat of the ox, 2.18 parts of the fat of the jaguar, and about 2.8 parts of the fat of the hog.

M. Chevreul next examines the change which is produced in the different kinds of fat respectively by the action of potash. All the kinds of fat are capable of being perfectly saponified, when excluded from the contact of the air: in all of them there was the production of the saponified fat and the sweet principle; no carbonic acid was produced, and the soaps formed contained no acetic acid, or only slight traces of it. The saponified fats had more tendency to crystallize in needles than the fats in their natural state; they were soluble in all proportions in boiling alcohol of the specific gravity of .821. The solution, like that of the saponified fat of the hog, contained both the margaric and the oleic acids. They were less fusible than the fats from which they were formed: thus, when human fat, after being saponified, was melted, the thermometer became stationary at 95°, when the fluid began to congeal; in that of the sheep, the thermometer fell to 118.5°, and rose to 122°; in that of the ox it remained stationary at 118.5°; and in that of the jaguar at 96.5°.

The saponified fat of the sheep and the ox had the same degree of solubility in potash and soda as that of the hog.

100 parts of the fat of the sheep when saponified were dissolved by	15.41 of potash.
100 parts of the same were dissolved by	10.27 of soda.
100 parts of the saponified fat of the ox were dissolved by	15.42 of potash.
100 parts of the same were dissolved by	10.24 of soda.
100 parts of the saponified fat of the hog were dissolved by	15.04 of potash.
100 parts of the same were dissolved by	10.29 of soda.

The following table contains the proportions of the saponified fat, and of the matter soluble in water, into which 100 parts of the fat are capable of being changed:—

Human fat.	
Saponified fat,	95
Soluble matter,	5
Fat of the sheep.	
Saponified fat,	95·1
Soluble matter,	4·9
Fat of the ox.	
Saponified fat	95
Soluble matter,	5
Fat of the hog.	
Saponified fat,	94·7
Soluble matter,	5·3

M. Chevreul next gives an account of the analysis of fat by alcohol.

The method of analysis employed was to expose the different kinds of fat to boiling alcohol, and to suffer the mixture to cool: a portion of the fat that had been dissolved was then separated in two states of combination; one with an excess of stearine was deposited, the other with an excess of elaïne remained in solution. The first was separated by filtration, and by distilling the filtered fluid, and adding a little water towards the end of the operation, we obtain the second in the retort, under the form of an alcoholic aqueous fluid. The distilled alcohol which had been employed in the analysis of human fat had no sensible odour; the same was the case with that which had served for the analysis of the fat of the ox, of the hog, and of the goose. The alcohol which had been employed in the analysis of the fat of the sheep had a slight odour of candle-grease.

The varieties of stearine from the different species of fat were found to possess the following properties:—They were all of a beautiful white colour; entirely, or almost without odour, insipid, and having no action upon litmus.—*Stearine from man.* The thermometer which was plunged into it when melted fell to 105.5°, and rose again to 120°. By cooling, the stearine crystallised in very fine needles, the surface of which was flat.—*Stearine of the sheep.* The thermometer fell to 104°, and rose again to 109.5°; it formed itself into a flat mass: the centre, which cooled more slowly than the edges, presented small and finely-radiated needles.—*Stearine of the ox.* The thermometer fell to 103° and rose again to 111°; it formed itself into a mass, the surface of which was flat, over which were dispersed a number of minute stars visible by the microscope; it was slightly semitransparent.—*Stearine of the hog.* It exhaled the odour of hog's-lard when it was melted. The thermometer fell to 100.5°, and rose again to 109.5°. By cooling, it was reduced into a mass, the surface of which was very unequal, and which appeared to be formed of small needles. When it cooled rapidly, the parts which touched the sides of the vessel had the semitransparency of coagulated albumen.—*Stearine of the goose.* The thermometer fell to 104°, and rose again to 109.5°; it was formed into a flat mass.

With respect to the solubility of these different bodies in alcohol, 100 parts of boiling alcohol, of the specific gravity of 0.7952, dissolved,

Of human stearine,	21·50 parts.
Of the stearine of the sheep,	16·07
Of the stearine of the ox,	15·48
Of the stearine of the hog,	18·25
Of the stearine of the goose,	36·00

Saponification by potash.

The human stearine produced, by saponification, .	Saponified fat,	94·9	It was fusible at 123·5°; it crystallized in small needles joined in the form of a funnel.
	Soluble matter,	5·1	The syrup of the sweet principle weighed 8·6, the acetate 0·3*.
Stearine of the sheep.	Saponified fat,	94·6	It began to become opaque at 129°, and the thermometer became stationary at 127.5°; it crystallized in small fine radiated needles.
	Soluble matter,	5·4	The syrup of the sweet principle weighed 8, the acetate 0·6; it had a rancid odour.
Stearine of the ox.	Saponified fat,	95·1	It began to become solid at 129°, but it was not perfectly so until 125·5; it crystallized in small needles united into flattened globules.
	Soluble matter,	4·9	The syrup of the sweet principle weighed 9·8, the acetate 0·3.
Stearine of the hog.	Saponified fat,	94·65	It began to grow solid at 129°, and the thermometer became stationary at 125·5°; it crystallized in small needles united into flattened globules.
	Soluble matter,	5·35	The syrup of the sweet principle weighed 9, the acetate 0·4.
Stearine of the goose.	Saponified fat,	94·4	It became solid at 119°; it crystallized in needles united in the form of a funnel.
	Soluble matter,	5·6	The syrup of the sweet principle weighed 8·2.

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* This means the salt which we obtain after having neutralized by barytes the product of the distillation of the aqueous fluid, which was procured from the soap that had been decomposed by tartaric acid.

All the soaps of stearine were analyzed by the same process as the soap of the fat from which they had been extracted: there was procured from them the pearly super-margarate of potash and the oleate; but the first was much more abundant than the second. The margaric acid of the stearines had precisely the same capacity for saturation as that which was extracted from the soaps formed of fat. The margaric acid of the stearine of the sheep was fusible at 144°, and that of the stearine of the ox at 143·5°; while the margaric acids of the hog and the goose had nearly the same fusibility with the margaric acid of the fat of these animals.

On Spermaceti, or, as M. Chevreul technically calls it, *cetine*. In the fifth memoir, in which we have an account of many of the properties of this substance, it was stated, that it is not easily saponified by potash, but that it is converted by this reagent into a substance which is soluble in water, but has not the saccharine flavour of the sweet principle of oils; into an acid analogous to the margaric, to which the name of *cetic* was applied; and into another acid, which was conceived to be analogous to the oleic. Since he wrote the fifth memoir, the author has made the following observations on this subject:—1. That the portion of the soap of cetine which is insoluble in water, or the cetate of potash, is in part gelatinous, and in part pearly; 2. That two kinds of crystals were produced from the cetate of potash which had been dissolved in alcohol: 3. That the cetate of potash exposed, under a bell glass, to the heat of a stove, produced a sublimate of a fatty matter which was not acid. From this circumstance, M. Chevreul was led to suspect, that the supposed cetic acid might be a combination, or a mixture of margaric acid and of a fatty body which was not acid. He accordingly treated a small quantity of it with barytic water, and boiled the soap which was formed in alcohol; the greatest part of it was not dissolved, and the alcoholic solution, when cooled, filtered, and distilled, produced a residuum of fatty matter which was not acid. The suspicion being thus confirmed, M. Chevreul determined to subject cetine to a new train of experiments. Being treated with boiling alcohol, a cetine was procured, which was fusible at 120°, and a yellow fatty matter which began to become solid at 89·5°, and which at 73·5° contained a fluid oil, which was separated by filtration.

Saponification of the Elaïnes by Potash.—The determination of the soluble matter which the elaïnes yield to water in the process of saponification, is much more difficult than the determination of the same point with respect to the stearines. The stearines are less subject to be changed than the elaïnes; it is less difficult to obtain the stearines in an uniformly pure state; besides, the saponified fats of the stearines being less fusible than the saponified elaïnes, it is more easy to weigh them without loss. The elaïnes of the sheep, the hog, the jaguar, and the goose, extracted by alcohol, yield by the action of potash,

Of saponified fat, 89 parts
Of soluble matter, 11

The elaïne of the ox extracted in the same manner yields,

Of saponified fat, 92·6 parts
Of soluble matter, 7·4

The different kinds of fat, considered in their natural state, are distinguished from each other by their colour, odour, and fluidity.

The stearines of the sheep, the ox, and the hog, have the same degree of solubility in alcohol; the stearine of man is a little more soluble, while that of the goose is twice as much so. The elaïnes of man, of the sheep, the ox, the jaguar, and the hog, have a specific gravity of about ·915; that of the goose of about ·929. The elaïnes of the sheep, the ox, and the hog, have the same solubility in alcohol; the elaïne of the goose is a little more soluble. On the other hand, the margaric acids of man, of the hog, of the jaguar, and of the goose, cannot be distinguished from each other; those of the sheep and the ox differ a few degrees in their melting point, and a little also in their form. As for the slight differences which the oleic acids present, they are not sufficiently precise for us to be able to particularize them. See Acid (Oleic).

M. Dupuy has shown that, in the distillations of oils, if the temperature be not raised to ebullition, a solid product is obtained, which constitutes three-fourths of the quantity of oil employed; while, if this point be exceeded, a liquid product is constantly formed, during the whole course of the operation. Thus with 100 parts of oil, the products were as follows:—

Solid · · · ·	76·470
Liquid · · · ·	23·529
Charcoal · · ·	3·676
	103·675

The solid matter is of a consistence approaching that of hog's lard; it is yellowish at the commencement of the operation, and of less consistence; but by degrees it acquires more, and becomes of a very fine white colour. *Annales de Chimie*, xxix. 319.

FAT LUTE. A compound of linseed oil and pipe clay, of a doughy consistence.

FECULA. See Starch.

FECULA. Green of plants. See Chlorophyle.

FELSPAR. This important mineral genus is distributed by Professor Jameson into four species, viz. prismatic felspar, pyramidal felspar, prismato-pyramidal felspar, and rhomboidal felspar.

I. Prismatic felspar has 9 sub-species; 1. Adularia; 2. Glassy felspar; 3. Ice-spar;

4. Common felspar; 5. Labradore felspar; 6. Compact felspar; 7. Clinkstone; 8. Earthy common felspar; and, 9. Porcelain earth.

1. *Adularia.* Colour greenish-white; iridescent; and in thin plates, pale flesh-red by transmitted light. Massive and crystallized. Primitive form; an oblique four-sided prism, with 2 broad and 2 narrow lateral planes; the lateral edges are 120° and 60°. Secondary forms; an oblique four-sided prism, a broad rectangular six-sided prism, a six-sided table, and a rectangular four-sided prism. Sometimes twin crystals occur. The lateral planes of the prism are longitudinally streaked. Lustre splendent, intermediate between vitreous and pearly. Cleavage threefold. Fracture imperfect conchoidal. Semitransparent. A beautiful pearly light is sometimes seen, when the specimen is viewed in the direction of the broader lateral planes. Refracts double. Harder then apatite, but softer than quartz. Easily frangible. Sp. gr. 2·5. It melts before the blowpipe, without addition, into a white-coloured transparent glass. Its constituents are, 64 silica, 20 alumina, 2 lime, and 14 potash.—*Vauquelin.*

It occurs in contemporaneous veins, or drusy cavities, in granite and gneiss, in the island of Arran, in Norway, Switzerland, France, and Germany. The finest crystals are found in the mountain of Stella, a part of St. Gothard. Rolled pieces, exhibiting a most beautiful pearly light, are collected in the island of Ceylon. Moonstone adularia is found in Greenland; and all the varieties in the United States. Under the name of moonstone it is worked by lapidaries. Another variety from Siberia is called sunstone by the jewellers. It is of a yellowish colour, and numberless golden spots appear distributed through its whole substance. These reflections of light are either from minute fissures, or irregular cleavages of the mineral. The aventurine felspar of Archangel appears to be also sunstone. It is the hyaloides of Theophrastus.

2. *Glassy felspar.* Colour greyish-white. Crystallized in broad rectangular four-sided prisms, bevelled on the extremities. Splendent and vitreous. Cleavage threefold. Fracture uneven. Transparent. Sp. gr. 2.57. It melts without addition into a grey semitransparent glass. Its constituents are 68 silica, 15 alumina, 14·5 potash, and 0·5 oxide of iron.—*Klapr.* It occurs imbedded in pitch-stone porphyry in Arran and Rum.

3. *Ice-spar.* Colour greyish-white. Massive, cellular and porous; and crystallized in small, thin, longish six-sided tables. The lateral planes are longitudinally streaked. Lustre vitreous. Cleavage imperfect. Translucent and transparent. Hard as common felspar, and easily frangible. It occurs along with nepheline, meionite, mica, and hornblende, at Monte Somma near Naples.

4. *Common felspar.* Colours white and red, of various shades: rarely green and blue. Massive, disseminated and crystallized, in a very oblique four-sided prism; an acute rhombus; elongated octohedron; a broad equiangular six-sided prism; a rectangular four-sided prism; and twin crystals; which forms are diversified by various bevelments and truncations. Cleavage threefold. Lustre more pearly than vitreous. Fracture uneven. Fragments rhomboidal; and have only four splendent faces. Translucent on the edges. Less hard than quartz. Easily frangible. Sp. gr. 2.57. It is fusible without addition into a grey semitransparent glass. Its constituents are as follows:

	Siberian green felspar.	Flesh-red felspar.	Felspar from Passau.
Silica,	62.83	66.75	60·25
Alumina,	17.02	17·50	22·00
Lime,	3.00	1·25	0·75
Potash,	13.00	12·00	14·00
Oxide of iron,	1.00	0·75 water,	1·00
	96.85	98·25	98·00
	Vauq.	*Rose.*	*Bucholz.*

Felspar is one of the most abundant minerals, as it forms a principal constituent part of granite and gneiss, and occurs occasionally mixed with mica-slate and clay-slate. It is also a constituent of whitestone and syenite. It forms the basis of certain porphyries. Greenstone is a compound of common felspar and hornblende. The most beautiful crystals of it occur in the Alps of Switzerland, in Lombardy, France, and Siberia, in veins of contemporaneous formation with the granite and gneiss rocks. It occurs abundantly in transition mountains, and in those of the secondary class. Under the name of petunse, it is an ingredient of Chinese porcelain. When the green varieties are spotted with white, they are named *aventurine felspar.* Another green variety from South America is called the Amazon-stone, from the river where it is found.

5. *Labradore felspar.* Colour grey of various shades. When light falls on it in certain directions, it exhibits a great variety of beautiful colours. It occurs massive, or in rolled pieces. Cleavage splendent. Fracture glistening. Lustre between vitreous and pearly. It breaks into rhomboidal fragments. Translucent in a very low degree. Less easily frangible than common felspar. Sp. gr. 2.6 to 2.7. It is less fusible than common felspar. It occurs in rolled masses of syenite, in which it is associated with common hornblende, hypersten, and magnetic ironstone, in the island of St. Paul on the coast of Labradore. It is found round Laurwig in Norway.

6. *Compact felspar.* Colours, white, gray, green, and red. Massive, disseminated, and crystallized in rectangular four-sided prisms. Lustre glistening, or glimmering. Fracture

splintery and even. Translucent only on the edges. Easily frangible. Sp. gr. 2·69. It melts with difficulty into a whitish enamel. Its constituents are, 51 silica, 30·5 alumina, 11·25 lime, 1·75 iron, .4 soda, 1·26 water.—*Klapr.* It occurs in mountain masses, beds and veins: in the Pentland hills, at Sala, Dannemora, and Hallefors in Sweden; in the Saxon Erze-gebirge, and the Hartz.

7. *Clinkstone;* which see.

8. *Earthy common felspar.* This seems to be disentegrated common felspar.

9. *Porcelain earth.* See CLAY.

II. *Pyramidal felspar.* See SCAPOLITE, and ELAOLITE.

III. *Prismato-pyramidal felspar.* See MEIONITE.

IV. *Rhomboidal felspar.* See NEPHELINE.

Chiastolite and sodalite have also been annexed to this species by Professor Jameson.

FERMENTATION. When aqueous combinations of vegetable or animal matter are exposed to ordinary atmospherical temperatures, they speedily undergo spontaneous changes, to which the generic name of *fermentation* has been given. Animal liquids alone, or mixed with vegetables, speedily become sour. The act which occasion this alteration is called acetous fermentation, because the product is, generally speaking, acetic acid, or vinegar. But when a moderately strong solution of saccharine matter, or saccharine matter and starch, or sweet juices of fruits, suffer this intestine change, the result is an intoxicating liquid, a beer, or wine; whence the process is called vinous fermentation. An ulterior change to which all moist animal and vegetable matter is liable, accompanied by the disengagement of a vast quantity of fetid gases, is called the putrefactive fermentation.

Each of these processes goes on most rapidly at a somewhat elevated temperature, such as 80° or 100° Fahr. It is for these reasons that, in tropical countries, animal and vegetable substances are so speedily decomposed.

As the ultimate constituents of vegetable matter are oxygen, hydrogen, and carbon; and of animal matter, the same three principles with azote, we can readily understand that all the products of fermentation must be merely new compounds of these three or four ultimate constituents. Accordingly, 100 parts of real vinegar, or acetic acid, are resolvable, by MM. Gay Lussac and Thenard's analysis, into 50·224 carbon + 46·911 hydrogen and oxygen, as they exist in water, + 2·863 oxygen in excess. In like manner, wines are all resolvable into the same ultimate components, in proportions somewhat different. The aeriform results of putrefactive fermentation are in like manner found to be, hydrogen, carbon, oxygen, and azote, variously combined, and associated with minute quantities of sulphur and phosphorus. The residuary matter consists of the same principles, mixed with the saline and earthy parts of animal bodies.

Lavoisier was the first philosopher who instituted, on right principles, a series of experiments to investigate the phenomena of fermentation, and they were so judiciously contrived, and so accurately conducted, as to give results comparable to those derived from the more rigid methods of the present day. Since then M. Thenard and M. Gay Lussac have each contributed most important researches. By the labours of these three illustrious chemists, those material metamorphoses, formerly quite mysterious, seem susceptible of a satisfactory explanation.

1. *Vinous fermentation.* As sugar is a substance of uniform and determinate composition, it has been made choice of for determining the changes which arise when its solution is fermented into wine or alcohol. Lavoisier justly regarded it as a true vegetable oxide, and stated its constituents to be, 8 hydrogen, 28 carbon, and 64 oxygen, in 100 parts. By two different analyses of Berzelius we have,

Hydrogen,	6·802	6·891
Carbon,	44·115	42·704
Oxygen,	49·083	50·405
	100·000	100·000

MM. Gay Lussac and Thenard's analysis gives,

Hydrogen,	6·90	57·53 water,
Oxygen,	50·63	
Carbon,	42·47	42.47
	100·00	100·00

It has been said, that sugar requires to be dissolved in at least 4 parts of water, and to be mixed with some yeast, to cause its fermentation to commence. But this is a mistake. Syrup stronger than the above will ferment in warm weather, without addition. If the temperature be low, the syrup weak, and no yeast added, acetous fermentation alone will take place. To determine the vinous, therefore, we must mix certain proportions of saccharine matter, water, and yeast, and place them in a proper temperature.

To observe the chemical changes which occur, we must dissolve 4 or 5 parts of pure sugar in 20 parts of water, put the solution into a matrass, and add 1 part of yeast. Into the mouth of the matrass a glass tube must be luted, which is recurved, so as to dip into the mercury of a pneumatic trough. If the apparatus be now placed in a temperature of from 70° to 80°, we shall speedily observe the syrup to become muddy, and a multitude of air bubbles to form all around the ferment. These unite, and attaching themselves to particles of the yeast, rise along with it to the surface, forming a stratum of froth. The yeasty matter will then disengage itself from the air, fall to the bottom of the vessel, to reacquire buoyancy a second time by attached air-bubbles, and thus in succession. If we operate on 3 or 4 ounces of sugar, the fermentation will be very rapid during the first ten or twelve hours; it will then slacken, and terminate in the course of a few days. At this period the matter being deposited which disturbed the transparency of the liquor, this will become clear.

The following changes have now taken place: 1. The sugar is wholly, and the yeast partially decomposed. 2. A quantity of alcohol and carbonic acid, together nearly in weight to the sugar, is produced. 3. A white matter is formed, composed of hydrogen, oxygen, and carbon, equivalent to about half the weight of the decomposed ferment. The carbonic acid passes over into the pneumatic apparatus; the alcohol may be separated from the vinous liquid by distillation, and the white matter falls down to the bottom of the matrass with the remainder of the yeast.

The quantity of yeast decomposed is very small. 100 parts of sugar require, for complete decomposition, only two and a half of that substance, supposed to be in a dry state. It is hence very probable, that the ferment, which has a strong affinity for oxygen, takes a little of it from the saccharine particles, by a part of its hydrogen and carbon, and thus the equilibrium being broken between the constituent principles of the sugar, these so react on each other, as to be transformed into alcohol and carbonic acid. If we consider the composition of alcohol, we shall find no difficulty in tracing the steps of this transformation. If we take 40 of carbon + 60 of water, or its elements, as the true constituents of sugar, instead of 42.47 + 57.53, and convert these weights into volumes, we shall have for the composition of that body, very nearly,

by weight,
1st, 1 volume vapour of carbon, = 0.416
1 volume vapour of water, = 0.625
or, 1 volume vapour of carbon,
1 ditto hydrogen gas,
$\frac{1}{2}$ volume oxygen;
or, multiplying each by 3,
3 volumes vapour of carbon,
3 ditto hydrogen,
$\frac{3}{2}$ ditto oxygen.

2d, Let us bear in mind, that alcohol is composed of

$$\text{1 vol. olefiant gas} = \left\{\begin{array}{l}\text{2 vols. vap. of carb.}\\ \text{2 vols. hydrogen.}\end{array}\right.$$

$$\text{1 vol. vap. of water} = \left\{\begin{array}{l}\text{1 vol. hydrogen,}\\ \tfrac{1}{2}\text{ vol. oxygen.}\end{array}\right.$$

3d, 1 vol. carbonic acid = 1 vol. oxygen + 1 vol. vapour of carbon.

4. Neglecting the minute products which the yeast furnishes, in the act of fermentation, let us regard only the alcohol and carbonic acid. We shall then see, on comparing the composition of sugar to that of alcohol, that to transform sugar into alcohol, we must withdraw from it one volume of vapour of carbon, and one volume of oxygen, which form by their union one volume of carbonic acid gas. Finally, let us reduce the volumes into weights, we shall find, that 100 parts of sugar ought to be converted, during fermentation, into 51·55 of alcohol, and 48·45 of carbonic acid.

Those who are partial to atomical language will see, that sugar may be represented by

	Atoms.		
3 vol. vap. of carb.	= 3 =	2·250	40·00
3 do. hydrogen,	= 3 =	0·375	6·66
$\frac{3}{2}$ do. oxygen,	= 3 =	3·000	53·33
		5·625	99.99
And alcohol, by			
2 vol. carbon, . ..	= 2 =	1·500	52·16
3 do. hydrogen, . .	= 3 =	0·375	13·04
$\frac{1}{2}$ do. oxygen, . .	= 1 =	1·000	34·80
		2·875	100·00
And carbonic acid, by			
1 vol. oxygen, . .	= 2 =	2·00	72·72
1 do. vap. of carb.	= 1 =	0·75	27·28
			100·00

If, therefore, from the sugar group, we take away one atom of carbon, and two of oxygen, to form the carbonic acid group below, we leave an atomic assemblage for forming alcohol, as in the middle. For this interesting development of the relation between the ultimate constituents of sugar on the one hand, and alcohol and carbonic acid on the other, we are indebted to M. Gay Lussac.

The following comparison, by the same philosopher, illustrates these metamorphoses:

Sulphuric ether is composed of

Dens. of vapour.

$$\left.\begin{array}{l}\text{2 vol. olefiant gas,} = 1{\cdot}9444\\ \text{1 vol. vap. of wat.} = 0{\cdot}6250\end{array}\right\} = 2{\cdot}5694$$

And alcohol is composed of

$$\left.\begin{array}{l}\text{2 vol. olefiant gas,} = 1{\cdot}9444\\ \text{2 do. vap. of water,} = 1{\cdot}2500\end{array}\right\} \div 2 = 1{\cdot}5072$$

Hence, to convert alcohol into ether, we have only to withdraw from it one-half of its constituent water.

Let us now see how far experiment agrees with the theoretic deduction, that 100 parts of sugar, by fermentation, should give birth to 51·55 of absolute alcohol, and 48·45 of carbonic acid. In Lavoisier's elaborate experiment, we find that 100 parts of sugar afforded,

Alcohol, . .	57·70
Carbonic acid, .	35·34
	93·04

Unfortunately, this great chemist has omitted to state the specific gravity of his alcohol.

If we assume it to have been 0·8293, as assigned for the density of *highly* rectified alcohol in the 8th table of the appendix to his *Elements*, we shall find 100 parts of it to contain, by Lowitz's table, 87.23 of absolute alcohol, if its temperature had been 60°. But as 54·5° was the thermometric point indicated in taking sp. gravities, we must reduce the density from 0·8293 to 0·827. We shall then find 100 parts of it to consist of 88 of absolute alcohol, and 12 of water. Hence, the 57.7 parts obtained by Lavoisier will become 50·776 of absolute alcohol, which is a surprising accordance with the theoretical quantity 51·55. But about four parts of the sugar, or 1-25th, had not been decomposed. If we add two parts of alcohol for this, we would have a small deviation from theory on the other side. There is no reasonable ground for questioning the accuracy of Lavoisier's experiments on fermentation. Any person who considers the excessive care he has evidently bestowed on them, the finished precision of his apparatus, and the complacency with which he compares "the substances submitted to fermentation, and the products resulting from that operation, as forming an algebraic equation," must be convinced that the results are deserving of confidence.

M. Thenard, in operating on a solution of 300 parts of sugar, mixed with 60 of yeast, at the temperature of 59°, has obtained such results as abundantly confirm the previous determination of Lavoisier. The following were the products:

Alcohol of 0·822,	171·5
Carbonic acid,	94·6
Nauseous residue,	12·0
Residual yeast,	40·0
	318·1
Loss,	41·9
	360·0

The latter two ingredients may be disregarded in the calculation, as the weight of the yeast is nearly equivalent to their sum.

Dividing 171·5 by 3, we have 57·17 for the weight of alcohol of 0·822 from 100 of sugar. In the same way we get 31·53 for the carbonic acid. Now, spirit of wine of 0·822 contains 90 per cent. of absolute alcohol. Whence we find 51·453 for the quantity of absolute alcohol by Thenard's experiment; being a perfect accordance with the theoretical deductions of M. Gay Lussac, made at a *subsequent* period.

By M. Lavoisier.	By M. Thenard.	By theory.
From 100 sugar.	From 100 do.	
Abs. alco. 50·776.	51·453	51·55

The coincidence of these three results seems perfectly decisive.

In determining the density of absolute alcohol, M. Gay Lussac had occasion to observe, that when alcohol is mixed with water, the density of the vapour is exactly the mean between the density of the alcoholic vapour and that of the aqueous vapour, notwithstanding the affinity which tends to unite them. An important inference flows from this observation. The experiments of M. de Saussure, as corrected by M. Gay Lussac's theory of volumes, demonstrate, that the absolute alcohol which they employed contains no separable portion of water, but what is essential to the existence of the liquid alcohol. Had any foreign water been present, then the specific gravity of the alcoholic vapour would have been proportionally diminished; for the vapour of water is less dense than that of alcohol, in the ratio of 1 to more than 2½. But since the sp. gravity of alcoholic vapour is precisely that which would result from the condensed union of two volumes vapour of carbon, three volumes of hydrogen, and half a volume of oxygen, it seems absurd to talk of such alcohol still containing 8·3 per cent. of water.

The writer of a long article on *brewing*, in the supplement to the 5th edition of the Encyclopædia Britannica, makes the following remarks in discussing M. Thenard's researches on fermentation. "Now, alcohol of the specific gravity 0·822 contains one-tenth of its weight of water, which can be separated from it; and if we suppose with Saussure, that absolute alcohol contains 8·3 per cent. of water, then the products of sugar decomposed by fermentation, according to Saussure's (Thenard's he means) experiments, are as follows:

Alcohol,	47·7
Carbonic acid,	35·34
	83·04
Or in 100 parts,	
Alcohol,	57·44
Carbonic acid,	42·56
	100·00

"This result approaches so nearly to that of Lavoisier, that there is reason to suspect that the coincidence is more than accidental." p. 480.

This insinuation against the integrity of one of the first chemists in France calls for reprehension. But farther, M. Gay Lussac's account of the nature of alcohol and its vapour was published a considerable time before the article *brewing* appeared. Indeed our author copies a considerable part of it, so that the above error is less excusable.

The ferment or yeast is a substance which separates under the form of flocculi, more or less viscid, from all the juices and infusions which experience the vinous fermentation. It is commonly procured from the beer manufactories, and is hence called the barm of beer. It may be easily dried, and is actually exposed for sale in Paris under the form of a firm but slightly cohesive paste, of a greyish-white colour. This pasty barm left to itself in a close vessel, at a temperature of from 55° to 70°, is decomposed, and undergoes in some days the putrid fermentation. Placed in contact, at that temperature, with oxygen in a jar inverted over mercury, it absorbs this gas in some hours, and there is produced carbonic acid and a little water. Exposed to a gentle heat, it loses more than two-thirds of its weight, becomes dry, hard, and brittle, and may in this state be preserved for an indefinite time. When it is more highly heated, it experiences a complete decomposition, and furnishes all the products which usually result from the distillation of animal substances.

It is insoluble in water and alcohol. Boiling water speedily deprives it of its power of readily exciting fermentation.—In fact, if we plunge the solid yeast into water for ten or twelve minutes, and place it afterwards in contact with a saccharine solution, this exhibits no symptom of fermentation for a long period. By that heat, the ferment does not seem to lose any of its constituents, or to acquire others. Its habitudes with acids and alkalis have not been well investigated. From Thenard's researches, the fermenting principle in yeast seems to be of a caseous or glutinous nature.

It is to the gluten that wheat flour owes its property of making a fermentable dough with water. This flour paste may indeed be regarded as merely a viscid and elastic tissue of gluten, the interstices of which are filled with starch, albumen, and sugar. We know that it is from the gluten that the dough derives its property of rising on the admixture of leaven. The leaven acting on the sweet principle of the wheat, gives rise in succession to the vinous and acetous fermentations, and of consequence to alcohol, acetic and carbonic acids. The latter gas tends to fly off, but the gluten resists its disengagement, expands like a membrane, forms a multitude of little cavities, which give lightness and sponginess to the bread. For the want of gluten, the flour of all those grains and roots which consist chiefly of starch are not capable of making raised bread, even with the addition of leaven or yeast. There does not appear to be any peculiar fermentation to which the name *panary* should be given.

When it is required to preserve fermented liquors in the state produced by the first stage of fermentation, it is usual to put them into casks before the vinous process is completely ended; and in these closed vessels a change very slowly continues to be made for many months, and perhaps for some years.

But if the fermentative process be suffered to proceed in open vessels, more especially if the temperature be raised to 90 degrees, the acetous fermentation comes on. In this, the oxygen of the atmosphere is absorbed; and the more speedily in proportion as the surfaces of the liquor are often changed by lading it from one vessel to another. The usual method consists in exposing the fermented liquor to the air in open casks, the bunghole of which is covered with a tile to prevent the entrance of the rain. By the absorption of oxygen which takes place, the inflammable spirit becomes converted into an acid. If the liquid be then exposed to distillation, pure vinegar comes over instead of ardent spirit.

When the spontaneous decomposition is suffered to proceed beyond the acetous process, the vinegar becomes viscid and foul; air is emitted with an offensive smell; volatile alkali flies off; an earthy sediment is deposited; and the remaining liquid, if any, is mere water. This is the putrefactive process.

The fermentation by which certain colouring matters are separated from vegetables, as in the preparation of woad and indigo, is carried much farther, approaching to the putrefactive stage.

It is not clearly ascertained what the yeast or ferment performs in this operation. It seems probable, that the fermentative process in considerable masses would be carried on progressively from the surface downwards; and would, perhaps, be completed in one part before it had perfectly commenced in another, if the yeast, which is already in a state of fermentation, did not cause the process to begin in every part at once. See BREAD, DISTILLATION, PUTREFACTION, ALCOHOL, WINE, ACID (ACETIC), VEGETABLE KINGDOM.

FERROCYANATES. See ACID (FERROPRUSSIC).

FERROCYANIC ACID. See ACID (FERROPRUSSIC).

FERROPRUSSIC ACID, and FERROPRUSSIATES. See ACID (FERROPRUSSIC).

FERRURETTED CHYAZIC ACID. The same as Ferroprussic.

FETSTEIN. Elaolite.

FIBRIN. A peculiar organic compound found both in vegetables and animals. Vauquelin discovered it in the juice of the papaw tree. It is a soft solid, of a greasy appearance, insoluble in water, which softens in the air, becoming viscid, brown, and semi-transparent. On hot coals it melts, throws out greasy drops, crackles, and evolves the smoke and odour of roasting meat. Fibrin is procured, however, in its most characteristic state from animal matter. It exists in chyle; it enters into the composition of blood; of it, the chief part of muscular flesh is formed; and hence it may be regarded as the most abundant constituent of the soft solids of animals.

To obtain it, we may beat blood as it issues from the veins with a bundle of twigs. Fibrin soon attaches itself to each stem, under the form of long reddish filaments, which become colourless by washing them with cold water. It is solid, white, insipid, without smell, denser than water, and incapable of affecting the hue of litmus or violets. When moist it possesses a species of elasticity; by desiccation it becomes yellowish, hard, and brittle. By distillation we can extract from it much carbonate of ammonia, some acetate, a fetid brown oil, and gaseous products; while there remains in the retort a very luminous charcoal, very brilliant, difficult of incineration, which leaves, after combustion, phosphate of lime, a little phosphate of magnesia, carbonate of lime, and carbonate of soda.

Cold water has no action on fibrin. Treated with boiling water, it is so changed as to lose the property of softening and dissolving in acetic acid. The liquor filtered from it, yields precipitates with infusion of galls, and the residue is white, dry, hard, and of an agreeable taste.

When kept for some time in alcohol of 0.810, it gives rise to an adipocerous matter, having a strong and disagreeable odour. This matter remains dissolved in the alcohol, and may be precipitated by water. Ether makes it undergo a similar alteration, but more slowly. When digested in weak muriatic acid, it evolves a little azote, and a compound is formed, hard, horny, and which, washed repeatedly with water, is transformed into another gelatinous compound. This seems to be a neutral muriate, soluble in hot water; whilst the first is an acid muriate, insoluble even in boiling water. Sulphuric acid, diluted with six times its weight of water, has similar effects. When not too concentrated, nitric acid has a very different action on fibrin. For example, when its sp. gr. is 1.25, there results from it at first a disengagement of azote, while the fibrin becomes covered with fat, and the liquid turns yellow. By digestion of 24 hours, the whole fibrin is attacked, and converted into a pulverulent mass of lemon-yellow colour, which seems to be composed of a mixture of fat and fibrin, altered and intimately combined with the malic and nitric or nitrous acids. In fact, if we put this mass on a filter, and wash it copiously with water, it will part with a portion of its acid, will preserve the property of reddening litmus, and will take an orange hue. On treating it afterwards with boiling alcohol, we dissolve the fatty matter; and putting the remainder in contact with chalk and water, an effervescence will be occasioned by the escape of carbonic acid, and malate or nitrate of lime will remain in solution.

Concentrated acetic acid renders fibrin soft at ordinary temperatures, and converts it by the aid of heat into a jelly, which is soluble in hot water, with the disengagement of a small quantity of azote. This solution is colourless, and possesses little taste. Evaporated to dryness, it leaves a transparent residue, which reddens litmus paper, and which cannot be dissolved even in boiling water, but by the medium of more acetic acid. Sulphuric, nitric, and muriatic acids, precipitate the animal matter, and form acid combinations. Potash, soda, ammonia, effect likewise the precipitation of this matter, provided we do not use too great an excess of alkali; for then the precipitated matter would be redissolved. Aqueous potash and soda gradually dissolve fibrin in the cold, without occasioning any perceptible change in its nature; but with heat they decompose it, giving birth to a quantity of ammoniacal gas, and other usual animal products. Fibrin does not putrefy speedily when kept in water. It shrinks on exposure to a considerable heat, and emits the smell of burning horn. It is composed, according to the analysis of MM. Gay Lussac and Thenard, of

Carbon,	53.360	
Azote,	19.934	
Oxygen,	19.685	} 22.14 water
Hydrogen,	7.021	} 4.56 hydrogen.

FIBROLITE. Colours white and grey; crystallized in rhomboidal prisms, the angles of whose planes are 80° and 100°. It is glistening internally. Principal fracture uneven. Harder than quartz. Sp. gr. 3.214. Its constituents are alumina 58.25, silica 38, iron and loss 3.75. It is found in the Carnatic.—*Jameson.*

FIGURESTONE. See BILDESTEIN.

FILTRATION. An operation, by means of which a fluid is mechanically separated from consistent particles merely mixed with it. It does not differ from straining.

An apparatus fitted up for this purpose is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, stuffed into the pipe of a funnel, will prevent the passage of grosser particles, and by that means render the fluid clearer which comes through. Sponge is still more effectual. A strip of linen rag wetted and hung over the side of a vessel containing a fluid, in such a manner as that one end of the rag may be immersed in the fluid, and the other end may remain without, below the surface, will act as a syphon, and carry over the clearer portion. Linen or woollen stuffs may either be fastened over the mouths of proper vessels, or fixed to a frame, like a sieve, for the purpose of filtering. All these are more commonly used by cooks and apothecaries than by philosophical chemists, who, for the most part, use the paper called cap paper, made up without size.

As the filtration of considerable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requisite to use a linen cloth, upon which the paper is applied and supported.

Precipitates and other pulverulent matters are collected more speedily by filtration than by subsidence. But there are many chemists who disclaim the use of this method, and avail themselves of the latter only, which is certainly more accurate, and liable to no objection, where the powders are such as will admit of edulcoration and drying in the open air.

Some fluids, as turbid water, may be purified by filtering through sand. A large earthen funnel, or stone bottle with the bottom beaten out, may have its neck loosely stopped with small stones, over which smaller may be placed, supporting layers of gravel increasing in fineness, and lastly covered to the depth of a few inches with fine sand, all thoroughly cleansed by washing. This apparatus is superior to a filtering stone, as it will cleanse water in large quantities, and may readily be renewed when the passage is obstructed, by taking out and washing the upper stratum of sand.

A filter for corrosive liquors may be constructed, on the same principles, of broken and pounded glass.

FIORITE. Pearl Sinter, a volcanic production, chiefly silica, in a stalactitical form.

FIRE. See Caloric and Combustion.

FIRE-DAMP. See Combustion and Carburetted Hydrogen.

FIREWORKS. Under Strontia, will be found a recipe for making the red fire for representing the effect of conflagrations in theatres. The following mixture, when burned before a reflector, sheds a beautiful green light upon all surrounding objects. It may also be employed in the changes of fireworks alternating with red and blue fire.

Take of Flowers of sulphur	13 parts
Nitrate of barytes	77
Chlorate of potash	5
Metallic arsenic	2
Charcoal	3
	100

The materials must be in fine powder, and thoroughly triturated together.

FISH-SCALES are composed of alternate layers of membrane and phosphate of lime.

FIXED AIR. Carbonic acid gas.

FIXITY. The property by which bodies resist the action of heat, so as not to rise in vapour.

FLAKE-WHITE. Pure carbonate of lead.

FLAME. See Combustion.

FLESH. The muscles of animals. They consist chiefly of fibrin, with albumen, gelatin, extractive, phosphate of soda, phosphate of ammonia, phosphate and carbonate of lime, and sulphate of potash. See Muscle.

FLINT. Colour generally grey, with occasionally zoned and striped delineations. Massive, in rolled pieces, tuberose and perforated. It rarely occurs in supposititious, hollow, pyramidal, or prismatic crystals. It occurs often in extraneous shapes, as echinites, coralites, madreporites, fungites, belemnites, mytilites, &c.; sometimes in lamellar concretions. Internal lustre glimmering. Fracture conchoidal. Fragments sharp-edged. Translucent. Harder than quartz. Easily frangible. Sp. gr. 2·50. Infusible without addition, but whitens and becomes opaque. Its constituents are 98 silica, 0·50 lime, 0·25 alumina, 0·25 oxide of iron, 1·0 loss. When two pieces of flint are rubbed together in the dark they phosphoresce, and emit a peculiar smell.

It occurs in primitive, transition, secondary, and alluvial mountains. In the first two in metalliferous and agate veins. In secondary countries it is found in pudding-stone, limestone, chalk, and amygdaloid. In chalk it occurs in great abundance in beds. These seem to have been both formed at the same time. Werner, however, is of opinion that the tuberose and many other forms have been produced by infiltration. In Scotland it occurs imbedded in secondary limestone in the island of Mull, and near Kirkaldy in Fifeshire. In England it abounds in alluvial districts in the form of gravel, or is imbedded in chalk. In Ireland it occurs in considerable quantities in secondary limestone. It is found in most parts of the world. Its principal use is for gun flints, the mechanical operations of which manufacture are fully detailed by Brogniart. The best flint for this purpose is the yellowish-grey. It is an ingredient in pottery, and chemists use it for mortars.

FLINTY-SLATE. Of this mineral there are two kinds, common flinty-slate, and Lydian stone.

1. *Common.* Colour ash-grey, with other colours, in flamed, striped, and spotted delineations. It is often traversed by quartz veins. Massive, and in lamellar concretions. Internally it is faintly glimmering. Fracture in the great, slaty; in the small, splintery. Translucent. Hard. Uncommonly difficultly frangible. Sp. gr. 2·63. It occurs in beds, in clay-slate and grey-wacke; and in roundish and angular masses in sandstone. It is found in different parts of the great tract of clay-slate and grey-wacke which extends from St. Abb's-head to Portpatrick; also in the Pentland hills near Edinburgh.

2. *Lydian stone.* Colour greyish-black, which passes into velvet-black. It occurs massive, and rolled in pieces with glistening surfaces. Internally it is glimmering. Fracture even. Opaque. Less hard than flint. Difficultly frangible. Sp. gr. 2·6. It occurs very frequently along with common flinty-slate in beds in clay-slate. It is found near Prague and Carlsbad in Bohemia, in Saxony, the Hartz, and at the Moorfoot and Pentland hills near Edinburgh. It is sometimes used as a touchstone for ascertaining the purity of gold and silver. See Assay.

FLOATSTONE. A sub-species of the indivisible quartz of Mohs. Spongiform quartz of Jameson. Colour white of various shades. In porous, massive, and tuberose forms. Internally it is dull. Fracture coarse, earthy. Feebly translucent on the edges. Soft, but its minute particles are as hard as quartz. Rather brittle. Easily frangible. Feels meagre and rough, and emits a grating noise, when the finger is drawn across it. Sp. gr. 0·49. Its constituents are, silica 98, carbonate of lime 2.—*Vauq.* It occurs incrusting flint, or in imbedded masses in a secondary limestone at St. Ouen near Paris.—*Jameson.*

FLOETZ ROCKS. Mineral formations of the secondary kind, composed of strata, for the most part horizontal and parallel to each other.

FLOS FERRI. A radiated variety of carbonate of lime, or of calc-spar.

FLOUR. The powder of the gramineous seeds. Its use as food is well known. See Bread.

FLOWERS. A general appellation used by the elder chemists to denote all such bodies as have received a pulverulent form by sublimation.

FLOWERS OF VEGETABLES. Dr. Lewis, in his notes on Neumann's Chemistry, gives a cursory account of many experiments made with a view to ascertain how far the colour of vegetable flowers might prove of use to the dyer. He found very few capable of being applied to valuable purposes.

The flowers of plants convert oxygen into carbonic acid with great rapidity. Thus those of the *Passiflora serratifolia* consume of oxygen in this way 18½ times their bulk, in 24 hours, when sheltered from the direct rays of the sun, at a temperature between 18° and 25° C. The male flowers of the cucumber 12 times their bulk; the female only 3½; the single red gilliflower (*Cheiranthus incanus*) 11; the single tuberose 9, and the *typha latifolia* 9.8. *T. de Saussure Ann. de Chimie*, xxi. 279.

FLUATES. Compounds of the salifiable bases with fluoric acid.

FLUIDITY. The state of bodies when their parts are very readily moveable, in all directions with respect to each other. See Caloric.

FLUOBORATES. Compounds of fluoboric acid with the salifiable bases.

FLUOBORIC ACID. See Acid (Fluoboric).

FLUOR. Octohedral fluor of Jameson. It is divided into three sub-species; compact fluor, foliated fluor, and earthy fluor.

1. *Compact.* Colours, greenish-grey and greenish-white. Massive. Dull or feebly glimmering. Fracture even. Fragments sharp-edged. Translucent. Harder than calcareous spar, but not so hard as apatite. Brittle, and easily frangible. Sp. gr. 3·17. It is found in veins, associated with fluor spar, at Stolberg in the Hartz.

2. *Foliated.* Colours, white, yellow, green, and blue. Green cubes appear with white angles. Massive, disseminated, and in distinct concretions. Crystallized in cubes, perfect or variously truncated and bevelled; in the rhomboidal dodecahedron, and the octohedron, or double four-sided pyramid. The crystals are generally placed on one another, and form druses; but are seldom single. Surface smooth and splendent, or drusy and rough. Internal lustre specular-splendent, or shining vitreous. Cleavage fourfold, equiangular, parallel with the planes of an octohedron. Fragments octohedral or tetrahedral. Translucent to transparent. Single refraction. Harder than calcareous spar, but not so hard as spatite. Brittle, and easily frangible. Sp. gr. 3·15. Before the blowpipe it generally decrepitates, gradually loses its colour and transparency, and melts without addition into a greyish-white glass. When two fragments are rubbed together they become luminous in the dark. When gently heated, it phosphoresces with a blue and green light. By ignition it loses its phosphorescent property. The violet blue variety from Nertschinsky, called *chlorophane*, when placed on glowing coals, does not decrepitate, but soon throws out a green light. Sulphuric acid evolves from pulverized fluor spar acid fumes which corrode glass. Its constituents, by Berzelius, are 72·1 lime, and 27·9 fluoric acid. It occurs principally in veins that traverse primitive, transition, and sometimes secondary rocks. It has been found only in four places in Scotland, near Monaltree in Aberdeenshire, in gneiss in Sunderland, in secondary porphyry near Gourock in Renfrewshire, and in the island of Papastour one of the Shetlands. It occurs much more abundantly in England, being found in all the galena veins that traverse the coal formation in Cumberland and Durham; in secondary or floetz limestone in Derbyshire; and it is the most common veinstone in the copper, tin, and lead veins, that traverse granite, clay-slate, &c. in Cornwall and Devonshire. It is also frequent on the Continent of Europe. It is cut into ornamental forms. It has also been used as a flux for ores; whence its name *fluor*.—*Jameson.*

3. *Earthy fluor.* Colour, greyish-white and violet-blue, sometimes very deep. It occurs generally in crusts investing some other mineral. Dull. Earthy. Friable. Its constituents are the same as the preceding. It occurs in veins along with fluor spar at Beeralstone in Devonshire; in Cumberland, in Saxony, and Norway.

FLUORIC ACID. See Acid (Fluoric).

FLUORIDES. Compounds of fluorine with the electro-positive elements, briefly spoken of by M. Dumas in the 31*st volume of the Annales de Chim. et Phys.* He obtains these compounds by treating the fluoride (fluate) of mercury or of lead with bodies more positive than these metals.

Fluoride of arsenic is a liquid exactly resembling the fuming liquor of Libavius, very volatile, heavier than water, becoming in this fluid fluoric and arsenious acids. It scarcely acts on glass; but immediately disintegrates the skin.

Fluoride of antimony is solid at ordinary temperatures, white as snow, more volatile than sulphuric acid, but less so than water.

Fluoride of phosphorus is a colourless fuming liquid, easily obtained in abundance by operating on fluoride of lead with phosphorus. Its composition corresponds to the protochloride of phosphorus. In the same way may be obtained the

Fluoride of sulphur.

These are compounds of the same kind as those obtained by M. Unverdorben, by treating the chromate of lead with (anhydrous) sulphuric acid, and fluate of lime, or common salt.

FLUORINE. The unknown radical of fluoric acid.

FLUOSILICATES. See ACID (FLUOSILICIC).

FLUOSILICIC ACID. See ACID (FLUORIC).

FLUX. A general term made use of to denote any substance or mixture added to assist the fusion of minerals. In the large way, limestone and fusible spar are used as fluxes. The fluxes made use of in assays, or philosophical experiments, consist usually of alkalis, which render the earthy mixtures fusible, by converting them into glass; or else glass itself in powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar is of service in some operations; though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large vessel.

White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed, and flies off with the tartaric acid, and the remainder consists of the potash in a state of considerable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this, the weight of the tartar is double that of the nitre; on which account the combustion is incomplete and a considerable portion of the tartaric acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where metallic ores are intended to be reduced, and effects this purpose, by combining with the oxygen of the oxide.

The advantage of M. Morveau's reducing flux, seems to depend on its containing no excess of alkali. It is made of eight parts of pulverized glass, one of calcined borax, and half a part of powder of charcoal. Care must be taken to use a glass which contains no lead. The white glasses contain in general a large proportion, and the green bottle glasses are not perhaps entirely free from it. See BLOWPIPE.

FORGE FURNACE. The forge furnace consists of a hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, the nozzle of which is inserted through a wall or parapet constructed for that purpose.

Black lead pots, or small furnaces of every desired form, may be placed, as occasions require, upon the hearth; and the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to urge the heat to almost any degree required.

FORMATION. In geology, an assemblage of mineral strata or masses, connected with each other, so as to form one whole or system, without any notable interruption, either in the period or nature of their production.

FORMIATES. Compounds of formic acid with the salifiable bases.

FORMIC ACID. See ACID (FORMIC).

FRACTURE. In mineralogy, the form and aspect of the surface produced by breaking off a piece of a mineral with the hammer. Werner divides the varieties of fracture into compact, fibrous, radiated, and foliated. The compact may be splintery, even, conchoidal, uneven, earthy, or hackly. The fibrous may be coarse or delicate, straight or curved, parallel or diverging; and the diverging again, is either stellular, scopiform, or promiscuous. The radiated fracture is broad or narrow, straight or curved, parallel, diverging, or promiscuous; and streaked or smooth.

FREEZING. See CALORIC, and CONGELATION.

FOSSIL COPAL, or Highgate resin. Its colour is pale muddy yellowish-brown. It occurs in irregular roundish pieces. Lustre resinous. Semitransparent. Brittle. Yields easily to the knife. Sp. gr. 1·046. When heated, it gives out a resinous aromatic odour, melts into a limpid fluid, takes fire at a lighted candle, and burns entirely away before the blowpipe. Insoluble in potash ley. Found in the bed of blue clay at Highgate near London.—*Aiken's Mineralogy.*

FRANKINCENSE. See OLIBANUM.

FRANKLINITE. A mineral resembling oxidulous iron. Metallic, black, and magnetic, but not with polarity. It occurs in grains or in granular masses composed of imperfect crystals. It is not hard; brittle; powder, deep red brown; sp. grav. 4.87. It consists of oxide of iron 66, brown oxide of manganese 16, oxide of zinc 17. The regular octohedron is its primary form. It occurs in New Jersey, accompanying the red oxide of zinc.—*Phillips' Mineralogy.*

FRENCH BERRIES. The fruit of the *Rhamnus infectorius,* called by the French *graines d'Avignon.* They give a pretty good yellow colour, but void of permanency. When used for dyeing, the cloth is prepared in the same manner as for weld.

FRIESLAND GREEN. Ammoniaco-muriate of copper, the same with Brunswick green. See Copper.

FRITT. The materials of glass are first mixed together, and then exposed to calcination by a degree of heat not sufficient to melt them. The mass is then called fritt.

FRUITS of VEGETABLES. Sap Green is prepared from the berries of buckthorn, and Annotto is obtained from the pellicles of the seeds of an American tree. See the words.

FULIGINOUS. Vapours which possess the property of smoke; namely, opacity, and the disposition to apply themselves to surrounding bodies in the form of a dark coloured powder.

FULLER'S EARTH. Colour greenish-white, and other shades of green. Massive. Dull. Fracture uneven. Opaque. Shining and resinous in the streak. Very soft. Sectile. Scarcely adheres to the tongue. Feels greasy. Sp. gr. 1·7 to 2·2. It falls into a powder with water, without the crackling noise which accompanies the disintegration of bole. It melts into a brown spongy scoria before the blowpipe. Its constituents are, 53 silica, 10 alumina, 1·25 magnesia, 0·50 lime, 0·10 muriate of soda, trace of potash, oxide of iron 9·75, water 24.—*Klaproth.* Bergmann found 24 alumina, and only 0·7 oxide of iron. In England it occurs in beds, sometimes above, sometimes below, the chalk formation; at Roswein in Upper Saxony, under strata of greenstone slate; and in different places in Germany it is found immediately under the soil. The best is found in Buckinghamshire and Surrey. When good, it has a greenish-white, or greenish-grey colour, falls into powder in water, appears to melt on the tongue like butter, communicates a milky hue to water, and deposits very little sand when mixed with boiling water. The remarkable detersive property on woollen cloth depends on the alumina, which should be at least one-fifth of the whole, but not much more than one-fourth, lest it become too tenacious.—*Jameson.*

FULMINATING and FULMINATION. In a variety of chemical combinations it happens that one or more of the principles assume the elastic state with such rapidity that the stroke against the displaced air produces a loud noise. This is called fulmination, or much more commonly detonation.

Fulminating gold, and fulminating powder, are the most common substances of this kind, except gunpowder. For the latter of these see the article Gunpowder. The fulminating powder is made by triturating in a warm mortar three parts by weight of nitre, two of carbonate of potash, and one of flowers of sulphur. Its effects, when fused in a ladle, and then set on fire, are very great. The whole of the melted fluid explodes with an intolerable noise, and the ladle is commonly disfigured, as if it had received a strong blow downwards.

If a solution of gold be precipitated by ammonia the product will be fulminating gold. Less than a grain of this, held over the flame of a candle, explodes with a very sharp and loud noise. This precipitate, separated by filtration, and washed, must be dried without heat, as it is liable to explode with no great increase of temperature; and it must not be put into a bottle closed with a glass stopple, as the friction of this would expose the operator to the same danger.

Fulminating silver may be made by precipitating a solution of nitrate of silver by lime water, drying the precipitate by exposure to the air for two or three days, and pouring on it liquid ammonia. When it is thus converted into a black powder, the liquid must be poured off, and the powder left to dry in the air. It detonates with the gentlest heat, or even with the slightest friction, so that it must not be removed from the vessel in which it is made. If a drop of water fall upon it, the percussion will cause it to explode. It was discovered by Berthollet.

Brugnatelli made a fulminating silver by powdering a hundred grains of nitrate of silver, putting the powder into a beer glass, and pouring on it, first an ounce of alcohol, then as much concentrated nitrous acid. The mixture grows hot, boils, and an ether is visibly formed, that changes into gas. By degrees the liquor becomes milky and opaque, and is filled with small white clouds. When all the grey powder has taken this form, and the liquor has acquired a consistency, distilled water must be added immediately to suspend the ebullition, and prevent the matter from being redissolved, and becoming a mere solution of silver. The white precipitate is then to be collected on a filter, and dried. The force of this powder greatly exceeds that of fulminating mercury. It detonates in a tremendous manner, on being scarcely touched with a glass tube, the extremity of which has been dipped in concentrated sulphuric acid. A single grain, placed on a lighted coal, makes a deafening report.* The same thing happens if it be placed on a bit of paper on an electric pile, and a spark drawn from it.

Fulminating mercury was discovered by Mr. Howard. A hundred grains are to be dissolved with heat in an ounce and half by measure of nitric acid. The solution, when cold, is to be poured on two ounce measures of alcohol, and heat applied till an effervescence is excited. As soon as the precipitate is thrown down, it must be collected on a filter, that the acid may not react on it; washed, and dried by a very gentle heat. It detonates with a very little heat or friction.

Three parts of chlorate of potash, and one of sulphur, triturated in a metal mortar, cause numerous successive detonations, like the cracks of a whip, the reports of a pistol, or the fire of musketry, according to the rapidity and force of the pressure employed. A few grains, struck with a hammer on an anvil, explode with a noise like that of a musket, and torrents of purple light appear round it. Thrown into concentrated sulphuric acid, it takes fire and burns with a white flame, but without noise.

Six parts of the chlorate, one of sulphur, and one of charcoal, detonate by the same means, but more strongly, and with a redder flame.

Sugar, gum, or charcoal, mixed with the chlorate, and fixed or volatile oils, alcohol, or ether, made into a paste with it, detonate very strongly by the stroke, but not by trituration. Some of them take fire, but slowly, and by degrees, in the sulphuric acid.

All those mixtures that detonate by the stroke, explode much more loudly if previously wrapped up in double paper.

Fulminations of the most violent kind require the agency of azote or nitrogen; as we see not only in its compounds with the oxides of gold, silver, and platina; but still more remarkably in its chloride and iodide. See NITROGEN and ANTIMONY.

FUMIGATIONS, to destroy contagious miasmata or effluvia. The most efficacious substance for this purpose is chlorine; next to it the vapour of nitric acid; and lastly, that of the muriatic. The fumes of heated vinegar, burning sulphur, or the smoke of exploded gunpowder, deserve little confidence as antiloimics. The air of dissecting rooms should be nightly fumigated with chlorine, whereby their atmosphere would be more wholesome and agreeable during the day.

Mr. Faraday having been employed to fumigate the General Penitentiary at Milbank, used the following method: One part by weight of common salt was well mixed with one part of black oxide of manganese. On this mixture, placed in a shallow earthen pan, 2 parts of oil of vitriol previously diluted with one part by weight (or about 2 parts by bulk) of water, and left till cold, were poured. Such a mixture, stirred with a stick, and made at 60° F. began in a few minutes to liberate chlorine, and continued to do so for four days.

The whole quantity of materials used was 700lb. of common salt, 700 of manganese, and 1400 of oil of vitriol. The space requiring fumigation amounted to nearly 2,000,000 cubic feet; and the surface of the walls, floors, cielings, &c. exclusive of furniture, bedding, &c. was about 1,200,000 square feet. This surface was principally stone and brick, most of which had been lime-washed. Mr. Faraday remarks, that probably much less chlorine would have been sufficient. *Journal of Science*, xviii. 92.

FUMING LIQUOR. The fuming liquors of Boyle and Libavius have been long known. To prepare that of Boyle, which is a hydroguretted sulphuret of ammonia, three parts of lime fallen to powder in the air, one of muriate of ammonia, and one of flowers of sulphur, are to be mixed in a mortar, and distilled with a gentle heat. The yellow liquor, that first comes over, emits fetid fumes. It is followed by a deeper coloured fluid, that is not fuming.

The fuming liquor of Libavius is made by amalgamating tin with half its weight of mercury, triturating this amalgam with an equal weight of corrosive muriate of mercury, and distilling by a gentle heat. A colourless fluid at first passes over: after this, a thick vapour is thrown out at one single jet with a sort of explosion, which condenses into a transparent liquor, that emits copious, white, heavy, acrid fumes, on exposure to the air. In a closely stopped bottle, no fumes from it are perceptible; but needle-shaped crystals form against the top of the bottle, so as frequently to close the aperture.

Cadet's fuming liquor is prepared by distilling equal parts of acetate of potash and arsenious acid, and receiving the product into glass bodies, kept cool by a mixture of ice and salt. The liquor produced, emits a very dense, heavy, fetid, noxious vapour, and inflames spontaneously in the open air.

FUNGATES. The saline compounds of a peculiar acid, which M. Braconnot has lately extracted from mushrooms.

FUNGIN. The fleshy part of mushrooms, deprived by alcohol and water of every thing soluble. It seems to be a modification of woody fibre.

FURNACE. See LABORATORY.

FUSCITE. A greyish or greenish-black opaque mineral. It crystallizes in prisms. Sp. grav. 2.5—3. It is found at Kallingeren, near Arendahl in Norway, in rolled masses of granular quartz.

FUSIBLE METAL. See ALLOY. A combination of 3 parts of lead, with 2 of tin and 5 of bismuth, melts at 197° F.

FUSIBILITY. That property by which bodies assume the fluid state.

Some chemists have asserted that fusion is simply a solution in caloric; but this opinion includes too many yet undecided questions, to be hastily adopted.

Fusibility of Metals, as given by M. Thenard.

		Centigr.	
1. Fusible below a red heat.	Mercury,	—39°	
	Potassium,	+58°	Gay Lussac and Thenard.
	Sodium,	90	
	Tin,	210	Newton.
	Bismuth,	256	
	Lead,	260	Biot.
	Tellurium,	A little less fusible than lead.—Klaproth.	
	Arsenic,	Undetermined.	
	Zinc,	370°	Brogniart.
	Antimony,	A little below a red heat.	
	Cadmium,		Stromeyer.
		Pyrometer of Wedgewood.	
2. Infusible below a red heat.	Silver,	20°	Kennedy.
	Copper,	27	Wedgewood.
	Gold,	32	
	Cobalt,	A little less difficult to melt than iron.	
	Iron,	130 158	Wedgewood. Sir G. M'Kenzie.
	Manganese,	160	Guyton.
	Nickel,		As manganese.—Richter.
	Palladium		
	Molybdenum,	Nearly infusible; and to be obtained at a forge heat, only in small buttons.	
	Uranium,		
	Tungsten,		
	Chromium,		
	Titanium,	Infusible at the forge furnace. Fusible at the oxyhydrogen blowpipe. See BLOWPIPE.	
	Cerium,		
	Osmium,		
	Iridium,		
	Rhodium,		
	Platinum,		
	Columbium,		

FUSION. The act of fusing. Also the state of a fused body.

FUSTET. The wood of the *rhus cotinus*, or Venus's sumach, yields a fine orange colour, but not at all durable.

FUSTIC, OR YELLOW WOOD. This wood, the *morus tinctoria*, is a native of the West Indies. It affords much yellow colouring matter, which is very permanent.

The yellow given by the fustic without any mordant is dull, and brownish, but stands well. The mordants employed with weld act on it in a similar manner, and by their means the colour is rendered more bright and fixed. The difference between them is, that the yellow of fustic inclines more to orange than that of weld; and, as it abounds more in colouring matter, a less quantity will suffice.

G

GABBRO. The name given by the Italian artists, and by M. de Buch, to a rock essentially composed of felspar and diallage, called by the French geologists EUPHOTIDE, which see.

GABBRONIT. Scapolite.

GADOLINITE. Prismatic gadolinite. —*Mohs.*

Its colours are velvet-black, and black of various shades. Massive and disseminated. Rarely crystallized. Its primitive figure seems to be an oblique four-sided prism, in which the obtuse angle is nearly 110°. This prism sometimes occurs with six lateral planes. Lustre resinous inclining to vitreous. Fracture conchoidal. Very faintly translucent on the thinnest edges, and then it appears blackish-green. Harder than felspar, but softer than quartz. Streak greenish-grey. Brittle; difficultly frangible. When pure it does not affect the magnet. Sp. gr. 4.0 to 4.2. It intumesces very much before the blowpipe, and at length melts into an imperfect slag, which is magnetical. It loses its colour in nitric acid, and gelatinizes. Its constituents are 25.8 silica, 45 yttria, 16.69 oxide of cerium, 10.26 oxide of iron, 0.60 volatile matter.—*Berzelius.* It occurs along with yttrotantalite at Ytterby in Sweden, in beds of a coarse granular red felspar, which are situated in mica slate; at Finbo, near Fahlun, also in Sweden, in a coarse granular granite, along with pyrophysalite and tin-stone.—*Jameson.*

GAHNITE. Automalite or octohedral corundum.

GALLITZINITE. Rutile. An ore of titanium.

GALBANUM exudes from the *bubon galbanum.* This juice comes over in masses, composed of white, yellowish, brownish-yellow, and brown tears, unctuous to the touch, softening betwixt the fingers; of a bitterish, somewhat acrid, disagreeable taste, and a very strong smell; generally full of bits of stalks, leaves, seeds, and other foreign matters.

Galbanum contains more of a resinous than gummy matter; one pound yields with alcohol upward of nine ounces and a half of resinous extract; but the gummy extract obtained by water from the same quantity, amounts only to about three ounces. The resin is hard, brittle, insipid, and inodorous: the gummy extract has somewhat of a nauseous relish; but could not be distinguished to be a preparation of galbanum. The whole smell, flavour, and specific taste of this juice, reside in an essential oil, which rises in distillation both with water and spirit, and gives a strong impregnation to both: from a pound of galbanum are obtained, by distillation with water, six drachms of actual oil, besides what is retained by the water. In this respect galbanum agrees with asafœtida, and differs from ammoniacum.

GALENA. Native sulphuret of lead. See Ores *of lead.*

GALL OF ANIMALS. See Bile.

GALL-STONES. Calculous concretions are not unfrequently formed in the gall bladder, and sometimes occasion great pain in their passage through the ducts into the duodenum, before they are evacuated. Of these stones there are four different kinds.

1. The first has a white colour, and when broken presents crystalline plates, or striæ, brilliant and white like mica, and having a soft greasy feel. Sometimes its colour is yellow or greenish; and it has constantly a nucleus of inspissated bile. Its sp. gravity is inferior to that of water: Gren found the specific gravity of one 0.803. When exposed to a heat considerably greater than that of boiling water, this crystallized calculus softens and melts, and crystallizes again when the temperature is lowered. It is altogether insoluble in water; but hot alcohol dissolves it with facility. Alcohol, of the temperature of 167°, dissolves one-twentieth of its weight of this substance; but alcohol, at the temperature of 60°, scarcely dissolves any of it. As the alcohol cools, the matter is deposited in brilliant plates, resembling talc or boracic acid. It is soluble in oil of turpentine. When melted, it has the appearance of oil, and exhales the smell of melted wax; when suddenly heated, it evaporates altogether in a thick smoke. It is soluble in pure alkalis, and the solution has all the properties of a soap. Nitric acid also dissolves it; but it is precipitated unaltered by water.

This matter, which is evidently the same with the crystals Cadet obtained from bile, and which he considered as analogous to sugar of milk, has a strong resemblance to spermaceti. Like that substance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars. Since it is contained in bile, it is not difficult to see how it may crystallize in the gall-bladder, if it happen to be more abundant than usual: and the consequence must be a gall-stone of this species. Fourcroy found a quantity of the same substance in the dried human liver. He called it adipocere.

2. The second species of biliary calculus is of a round or polygonal shape, often of a grey colour externally, and brown within. It is formed of concentric layers of a matter which seems to be inspissated bile; and there is usually a nucleus of the white crystalline matter at the centre. For the most part, there are many of this species of calculus in the gall-bladder together; indeed it is frequently filled with them. The calculi belonging to this species are often light and friable, and of a brownish-red colour. The gall-stones of oxen used by painters belong to this species. These are also adipocere.

3. The third species of calculi are most numerous of all. Their colour is often deep brown or green; and when broken, a number of crystals of the substance resembling spermaceti are observable, mixed with inspissated bile. The calculi belonging to these three species are soluble in alkalis, in soap ley, in alcohol, and in oils.

4. Concerning the fourth species of gall-stone, very little is known with accuracy. Dr. Saunders tells us, that he has met with some gall-stones insoluble both in alcohol and oil of turpentine; some of which do not flame, but become red, and consume to ashes like charcoal. Haller quotes several examples of similar calculi. Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with much attention.

Soaps have been proposed as solvents for these calculi. The academy of Dijon has published the success of a mixture of essence of turpentine and ether. See Cholesterine.

GALL OF GLASS. Glass gall, called also Sandiver. The salt skimmed off the surface of glass while in fusion.

GALLS. These are the protuberances produced by the puncture of an insect on plants and trees of different kinds. Some of them are hard, and termed nut-galls; others are soft and spongy, and called berry-galls, or apple-galls. The best are the nut-galls of the oak, and those brought from Aleppo are preferred. These are not smooth on the surface, but tubercular, small, and heavy; and should have a bluish or blackish tinge.

Deyeux investigated the properties of galls with considerable care; and more lately Sir H. Davy has examined the same subject. The strongest infusion Sir H. Davy could obtain at 56° F. by repeated infusion of distilled water, on the best Aleppo galls, broken into small pieces, was of the specific gravity of 1.068. Four hundred grains of this infusion, evaporated at a heat below 200°, left 53 of solid matter, which consisted of about 0.9 tannin, and 0·1 gallic acid, united to a portion of extractive matter. One hundred grains of the solid matter left, by incineration, nearly 4⅔, which were chiefly calcareous matter, mixed with a small portion of fixed alkali.

From 500 grains of Aleppo galls Sir H. Davy obtained, by infusion as above, 185 grains of solid matter, which on analysis appeared to consist of tannin 130; mucilage, and matter rendered insoluble by evaporation, 12; gallic acid, with a little extractive matter, 31; remainder, calcareous earth and saline matter, 12.

The use of galls in dyeing is very extensive, and they are one of the principal ingredients in making ink. Powdered galls made into an ointment with hog's lard are a very efficacious application in piles. They are sometimes given internally as an astringent; and in the intermittents, where the bark has failed. The tubercles, or knots, on the roots of young oaks, are said to possess the same properties as the nut-galls, and to be produced in a similar manner.

For their acid, see ACID (GALLIC).

GALVANISM. The following article is chiefly extracted from a paper, which was read by me at the Glasgow Literary Society, December 10, 1818, and published in the Journal of Science and the Arts of the following January. I have now subjoined a few further observations, on the application of voltaic electricity to the resuscitation of the suspended functions of life.

Convulsions accidentally observed in the limbs of dead frogs originally suggested to Galvani the study of certain phenomena, which from him have been styled Galvanic. He ascribed these movements to an electrical fluid or power, innate in the living frame, or capable of being evolved by it, which he denominated animal electricity. The *Torpedo*, *Gymnotus*, and *Silurus Electricus*, fish endowed with a true electrical apparatus, ready to be called into action by an effort of their will, were previously known to the naturalist, and furnished plausible analogies to the philosopher of Bologna. Volta, to whom this science is indebted for the most brilliant discoveries on its principles, as well as for its marvellous apparatus, justly called by his name, advanced powerful arguments against the hypothesis of Galvani. He ascribed the muscular commotions, and other phenomena, to the excitation of common electricity, by arrangements previously unthought of by the scientific world; merely by the mutual contact of dissimilar bodies, metals, charcoal, and animal matter, applied either to each other, or conjoined with certain fluids. And at the present day, perhaps the only facts which seem difficult to reconcile with the beautiful theory of electromotion, invented by the Pavian professor, are some experiments of Aldini, the nephew of the original discoverer.

In these experiments, neither metals nor charcoal were employed. Very powerful muscular contractions seem to have been excited, in some of the experiments, by bringing a part of a warm-blooded, and of a cold-blooded animal, into contact with each other; as the nerve and muscle of a frog, with the bloody flesh of the neck of a newly decapitated ox. In other experiments, the nerves and muscles of the same animal seem to have operated Galvanic excitation; and again, the nerve of one animal acted with the muscle of another. He deduces from his experiments an inference in favour of his uncle's hypothesis, that a proper animal electricity is inherent in the body, which does not require the assistance of any external agent for its development. Should we admit the reality of these results, we may perhaps venture to refer them to a principle analogous to Sir H. Davy's pile, or voltaic circuit, of two dissimilar liquids and charcoal. This part of the subject is however involved in deep obscurity.

Many experiments have been performed, in this country and abroad, on the bodies of criminals, soon after their execution. Vassali, Julio, and Rossi, made an ample set, on several bodies decapitated at Turin. They paid particular attention to the effect of galvanic electricity on the heart, and other involuntary muscles: a subject of much previous controversy. Volta asserted, that these muscles are not at all sensible to this electric power. Fowler maintained, that they were affected; but with difficulty and in a slight degree. This opinion was confirmed by Vassali; who further showed, that the muscles of the stomach, and intestines, might thus also be excited. Aldini, on the contrary, declared, that he could not affect the heart by his most powerful galvanic arrangements.

Most of the above experiments were however made, either without a voltaic battery, or with piles, feeble in comparison with those now employed. Those indeed performed on the body of a criminal, at Newgate, in which the limbs were violently agitated; the eyes opened and shut; the mouth and jaws worked about, and the whole face thrown into frightful convulsions, were made by Aldini, with, I believe, a considerable series of voltaic plates.

A circumstance of the first moment, in my opinion, has been too much overlooked in experiments of this kind,—that a muscular mass through which the galvanic energy is directly transmitted, exhibits very weak contractile movements, in comparison with those which can be excited by passing the influence along the principal nerve of the muscle. Inattention to this important distinction, I conceive to be the principal source of the slender effects hitherto produced in such experiments on the heart, and other muscles, independent of the will. It ought also to be observed, that too little distinction has been made between the positive and negative poles of the battery; though there are good reasons for supposing, that their powers on muscular contraction are by no means the same.

According to Ritter, the electricity of the positive pole augments, while the negative diminishes the actions of life. Tumefaction of parts is produced by the former; depression by the latter. The pulse of the hand, he says, held a few minutes in contact with the positive pole, is strengthened; that of the one in contact with the negative is enfeebled; the former is accompanied with a sense of heat; the latter with a feeling of coldness. Objects appear to a positively electrified eye, larger, brighter, and red; while to one negatively electrified, they seem smaller, less distinct, and bluish,—colours indicating opposite extremities of the prismatic spectrum. The acid and alkaline tastes, when the tongue is acted on in succession by the two electricities, are well known, and have been ingeniously accounted for by Sir H. Davy, in his admirable Bakerian Lectures. The smell of oxymuriatic acid, and of ammonia, are said by Ritter, to be the opposite odours, excited by the two opposite poles; as a full body of sound and a sharp tone are the corresponding affects on the ears. These experiments require verification.

Consonant in some respects, though not in all, with these statements, are the doctrines taught by a London practitioner, experienced in the administration of medical electricity. He affirms, that the influence of the electrical fluid of our common machines in the cure of disease, may be referred to three distinct heads; first, the form of *radii*, when projected from a point positively electrified; secondly, that of a star, or the negative fire, concentred on a brass ball; thirdly, the Leyden explosion. To each of these forms he assigns a specific action. The first acts as a sedative, allaying morbid activity; the second as a stimulant; and the last has a deobstruent operation, in dispersing chronic tumours. An ample narrative of cases is given in confirmation of these general propositions. My own experience leads me to suppose, that the negative pole of a voltaic battery gives more poignant sensations than the positive.

But, unquestionably, the most precise and interesting researches on the relation between voltaic electricity and the phenomena of life, are those contained in Dr. Wilson Philip's Dissertations in the Philosophical Transactions, as well as in his Experimental Inquiry into the Laws of the Vital Functions, more recently published.

In his earlier researches he endeavoured to prove, that the circulation of the blood, and the action of the involuntary muscles, were independent of the nervous influence. In a late paper, read in January 1816, he showed the immediate dependence of the secretory functions on the nervous influence.

The eighth pair of nerves distributed to the stomach, and subservient to digestion, were divided by incisions in the necks of several living rabbits. After the operation, the parsley which they ate remained without alteration in their stomachs; and the animals, after evincing much difficulty of breathing, seemed to die of suffocation. But when in other rabbits, similarly treated, the galvanic power was transmitted along the nerve, below its section, to a disc of silver, placed closely in contact with the skin of the animal, opposite to its stomach, no difficulty of breathing occurred. The voltaic action being kept up for twenty-six hours, the rabbits were then killed, and the parsley was found in as perfectly digested a state, as that in healthy rabbits fed at the same time; and their stomachs evolved the smell peculiar to that of a rabbit during digestion. These experiments were several times repeated with similar results.

Hence it appears that the galvanic energy is capable of supplying the place of the nervous influence, so that, while under it, the stomach, otherwise inactive, digests food as usual. I am not, however, willing to adopt the conclusion drawn by its ingenious author, that the "identity of galvanic electricity and nervous influence is established by these experiments." They clearly show a remarkable analogy between these two powers, since the one may serve as a substitute for the other. It might possibly be urged by the anatomist, that as the stomach is supplied by twigs of other nerves, which communicate under the place of Dr. Philip's section of the *par vagum*, the galvanic fluid may operate merely as a powerful stimulus, exciting those slender twigs to perform such an increase of action, as may compensate for the want of the principal nerve. The above experiments were repeated on dogs, with like results; the battery never being so strong as to occasion painful shocks.

The removal of dyspnœa, as stated above, led him to try galvanism as a remedy in asthma. By transmitting its influence from the nape of the neck to the pit of the stomach, he gave decided relief in every one of twenty-two cases, of which four were in private practice, and eighteen in the Worcester Infirmary. The power employed varied from ten to twenty-five pairs.

The general inferences deduced by him from his multiplied experiments are, that voltaic electricity is capable of effecting the formation of the secreted fluids when applied to the blood in the same way in which the nervous influence is applied to it; and that it is capable of occasioning an evolution of caloric from arterial blood. When the lungs are deprived of the nervous influence, by which their function is impeded, and even destroyed, when digestion is interrupted, by withdrawing this influence from the stomach, these two vital functions are renewed by exposing them to the influence of a galvanic trough. "Hence," says he, "galvanism seems capable of performing all the functions of the nervous influence in the animal economy; but obviously it cannot excite the functions of animal life, unless when acting on parts endowed with the living principle."

These results of Dr. Philip have been recently confirmed by Dr. Clarke Abel, of Brighton, who employed, in one of the repetitions of the experiments, a comparatively small, and in the other a considerable degree of galvanism. In the former, although the galvanism was not of sufficient power to occasion evident digestion of the food, yet the efforts to vomit, and the difficulty of breathing, constant effects of dividing the eighth pair of nerves, were prevented by it. These symptoms recurred when it was discontinued, and vanished on its reapplication. "The respiration of the animal," he observes, "continued quite free during the experiment, except when the disengagement of the nerves from the tin-foil rendered a short suspension of the galvanism necessary during their readjustment." "The non-galvanised rabbit breathed with difficulty, wheezed audibly, and made frequent attempts to vomit." In the latter experiment, in which the greater power of galvanism was employed, digestion went on as in Dr. Philip's experiments.—*Jour. Sc.* ix.

M. Gallois, an eminent French physiologist, had endeavoured to prove that the motion of the heart depends entirely upon the spinal marrow, and immediately ceases when the spinal marrow is removed or destroyed. Dr. Philip appears to have refuted this notion by the following experiments. Rabbits were rendered insensible by a blow on the occiput; the spinal marrow and brain were then removed, and the respiration kept up by artificial means; the motion of the heart, and the circulation, were carried on as usual. When spirit of wine, or opium, was applied to the spinal marrow or brain, the rate of the circulation was accelerated.

These general physiological views will serve, I hope, as no inappropiate introduction to the detail of the galvanic phenomena exhibited here, on the 4th of November, in the body of the murderer Clydesdale; and they may probably guide us to some valuable practical inferences.

The subject of these experiments was a middle-sized, athletic, and extremely muscular man, about thirty years of age. He was suspended from the gallows nearly an hour, and made no convulsive struggle after he dropped; while a thief, executed along with him, was violently agitated for a considerable time. He was brought to the anatomical theatre of our university in about ten minutes after he was cut down. His face had a perfectly natural aspect, being neither livid nor tumefied; and there was no dislocation of his neck.

Dr. Jeffray, the distinguished professor of anatomy, having on the preceding day requested me to perform the galvanic experiments, I sent to his theatre with this view, next morning, my *minor* voltaic battery, consisting of 270 pairs of four inch plates, with wires of communication, and pointed metallic rods with insulating handles, for the more commodious application of the electric power. About five minutes before the police officers arrived with the body, the battery was charged with a dilute nitro-sulphuric acid, which speedily brought it into a state of intense action. The dissections were skilfully executed by Mr. Marshall, under the superintendence of the professor.

Exp. 1. A large incision was made into the nape of the neck, close below the *occiput*. The posterior half of the *atlas vertebra* was then removed by bone forceps, when the spinal marrow was brought into view. A profuse flow of liquid blood gushed from the wound, inundating the floor. A considerable incision was at the same time made in the left hip, through the great gluteal muscle, so as to bring the sciatic nerve into sight; and a small cut was made in the heel. From neither of these did any blood flow. The pointed rod connected with one end of the battery was now placed in contact with the spinal marrow, while the other rod was applied to the sciatic nerve. Every muscle of the body was immediately agitated with convulsive movements, resembling a violent shuddering from cold. The left side was most powerfully convulsed at each renewal of the electric contact. On moving the second rod from the hip to the heel, the knee being previously bent, the leg was thrown out with such violence as nearly to overturn one of the assistants, who in vain attempted to prevent its extension.

Exp. 2. The left phrenic nerve was now laid bare at the outer edge of the *sternothyroideus* muscle, from three to four inches above the clavicle; the cutaneous incision having been made by the side of the sternocleidomastoideus. Since this nerve is distributed to the diaphragm, and since it communicates with the heart through the eighth pair, it was expected, by transmitting the galvanic power along it, that the respiratory process would be renewed. Accordingly, a small incision having been made under the cartilage of the seventh rib, the point of the one insulating rod was brought into contact with the great head of the diaphragm, while the other point was applied to the phrenic nerve in the neck. This muscle, the main agent of respiration, was instantly contracted, but with less force than was expected. Satisfied, from ample experience on the living body, that more powerful effects can be produced in galvanic excitation, by leaving the extreme communicating rods in close contact with the parts to be operated on, while the electric chain or circuit is completed by running the end of the wires along the top of the plates in the last trough of either pole, the other wire being steadily immersed in the last cell of the opposite pole, I had immediate recourse to this method. The success of it was truly wonderful. Full, nay, laborious breathing, instantly commenced. The chest heaved, and fell; the belly was protruded, and again collapsed, with the relaxing and retiring diaphragm. This process was continued, without interruption, as long as I continued the electric discharges.

In the judgment of many scientific gentlemen who witnessed the scene, this respiratory experiment was perhaps the most striking ever made with a philosophical apparatus. Let it also be remembered, that for full half an hour before this period, the body had been well nigh drained of its blood, and the spinal marrow severely lacerated. No pulsation could be perceived meanwhile at the heart or wrist; but it may be supposed, that but for the evacuation of the blood,—the essential stimulus of that organ,—this phenomenon might also have occurred.

Exp. 3. The supra-orbital nerve was laid bare in the forehead, as it issues through the supra-ciliary *foramen*, in the eyebrow: the one conducting rod being applied to it, and the other to the heel, most extraordinary grimaces were exhibited every time that the electric discharges were made, by running the wire in my hand along the edges of the last trough, from the 220th to the 270th pair of plates: thus fifty shocks, each greater than the preceding one, were given in two seconds. Every muscle in his countenance was simultaneously thrown into fearful action; rage, horror, despair, anguish, and ghastly smiles, united their hideous expression in the murderer's face, surpassing far the wildest representations of a Fuseli or a Kean. At this period several of the spectators were forced to leave the apartment from terror or sickness, and one gentleman fainted.

Exp. 4. The last galvanic experiment consisted in transmitting the electric power from the spinal marrow to the ulnar nerve, as it passes by the internal condyle at the elbow: the fingers now moved nimbly, like those of a violin performer; an assistant, who tried to close the fist, found the hand to open forcibly, in spite of his efforts. When the one rod was applied to a slight incision in the tip of the fore-finger, the fist being previously clenched, that finger extended instantly; and from the convulsive agitation of the arm, he seemed to point to the different spectators, some of whom thought he had come to life.

About an hour was spent in these operations.

In deliberating on the above galvanic phenomena, we are almost willing to imagine, that if, without cutting into and wounding the spinal marrow and blood-vessels in the neck, the pulmonary organs had been set a-playing at first, (as I proposed), by electrifying the phrenic nerve, (which may be done without any dangerous incision), there is a probability that life might have been restored. This event, however little desirable with a murderer, and perhaps contrary to law, would yet have been pardonable in one instance, as it would have been highly honourable and useful to science. From the accurate experiments of Dr. Philip it appears, that the action of the diaphragm and lungs is indispensable towards restoring the suspended action of the heart and great vessels, subservient to the circulation of the blood.

It is known, that cases of death-like lethargy, or suspended animation, from disease and accidents, have occurred, where life has returned, after longer interruption of its functions than in the subject of the preceding experiments. It is probable, when apparent death supervenes from suffocation with noxious gases, &c. and when there is no organic lesion, that a judiciously directed galvanic experiment will, if any thing will, restore the activity of the vital functions. The plans of administering voltaic electricity hitherto pursued in such cases are, in my humble apprehension, very defective. No advantage, we perceive, is likely to accrue from passing electric discharges across the chest, directly through the heart and lungs. On the principles so well developed by Dr. Philip, and now illustrated on Clydesdale's body, we should transmit along the channel of the nerves, that substitute for nervous influence, or that power which may perchance awaken its dormant faculties. Then, indeed, fair hopes may be formed of deriving extensive benefit from galvanism; and of raising this wonderful agent to its expected rank among the ministers of health and life to man.

I would, however, beg leave to suggest another nervous channel, which I conceive to be a still readier and more powerful one, to the action of the heart and lungs, than the phrenic nerve. If a longitudinal incision be made, as is frequently done for aneurism, through the integuments of the neck at the outer edge of the *sterno-mastoideus* muscle, about half way between the clavicle and angle of the lower jaw; then on turning over the edge of this muscle, we bring into view the throbbing carotid, on the outside of which, the *par vagum*, and great sympathetic nerve, lie together in one sheath. Here, therefore, they may both be directly touched and pressed by a blunt metallic conductor. These nerves communicate directly, or indirectly, with the phrenic; and the superficial nerve of the heart is sent off from the sympathetic.

Should, however, the phrenic nerve be taken, that of the left side is the preferable of the two. From the position of the heart, the left phrenic differs a little in its course from the right. It passes over the *pericardium*, covering the *apex* of the heart.

While the point of one metallic conductor is applied to the nervous cords above described, the other knob ought to be firmly pressed against the side of the person, immediately under the cartilage of the seventh rib. The skin should be moistened with a solution of common salt, or what is better, a hot saturated solution of sal ammoniac, by which means, the electric energy will be more effectually conveyed through the cuticle so as to complete the voltaic chain.

To lay bare the nerves above described, requires, as I have stated, no formidable incision, nor does it demand more anatomical skill, or surgical dexterity, than every practitioner of the healing art ought to possess. We should always bear in mind, that the subject of experiment is at least insensible to pain; and that life is at stake, perhaps irrecoverably gone. And assuredly, if we place the risk and difficulty of the operation in competition with the blessings and glory consequent on success, they will weigh as nothing, with the intelligent and humane. It is possible, indeed, that two small brass knobs, covered with cloth moistened with solution of sal ammoniac, pressed above and below, on the place of the nerve, and the diaphragmatic region, may suffice, without any surgical operation: It may first be tried.

Immersion of the body in cold water accelerates greatly the extinction of life arising from suffocation; and hence less hope need be entertained of recovering drowned persons after a considerable interval, than when the vital heat has been suffered to continue with little abatement. None of the ordinary practices judiciously enjoined by the Humane Society should ever on such occasions be neglected. For it is surely culpable to spare any pains which may contribute, in the slightest degree, to recall the fleeting breath of man to its cherished mansion.

My attention has been again particularly directed to this interesting subject, by a very flattering letter which I lately received from the learned Secretary of the Royal Humane Society.

In the preceding account, I had accidentally omitted to state a very essential circumstance relative to the electrization of Clydesdale. The paper indeed was very rapidly written, at the busiest period of my public prelections, to be presented to the society, as a substitute for the essay of an absent friend, and was sent off to London the morning after it was read.

The positive pole or wire connected with the zinc end of the battery was that which I applied to the nerve; and the negative, or that connected with the copper end, was that which I applied to the muscles. This is a matter of primary importance, as the following experiments will prove.

Prepare the posterior limbs of a frog for voltaic electrization, leaving the crural nerves connected, as usual, to a detached portion of the spine. When the excitability has become nearly exhausted, plunge the limbs into the water of one wine glass, and the crural nerves with their pendent portion of spine into that of the other. The edges of the two glasses should be almost in contact. Then taking a rod of zinc in one hand, and a rod of silver (or a silver tea-spoon) in the other, plunge the former into the water of the limbs' glass, and the latter into that of the nerves' glass, without touching the frog itself, and gently strike the dry parts of the bright metals together. Feeble convulsive movements, or mere twitching of the fibres, will be perceived at every contact. Reverse now the position of the metallic rods, that is, plunge the zinc into the nerves' glass, and the silver into the other. On renewing the contact of the dry surfaces of the metal now, very lively convulsions will take place; and if the limbs are skilfully disposed in a narrowish conical glass, they will probably spring out to some distance. This interesting experiment may be agreeably varied in the following way, with an assistant operator: Let that person seize, in the moist fingers of his left hand, the spine and nervous cords of the prepared frog; and in those of the right hand, a silver rod; and let the other person lay hold of one of the limbs with his right hand, while he holds a zinc rod in the moist fingers of the left. On making the metallic contact, feeble convulsive twitchings will be perceived, as before. Holding still the frog as above, let them merely exchange the pieces of metal. On renewing the contacts now, lively movements will take place, which become very conspicuous, if one limb be held nearly horizontal, while the other hangs freely down. At each touch of the voltaic pair, the drooping limb will start up, and strike the hand of the experimenter.

It is evident, therefore, that for the purposes of resuscitating dormant irritability of nerves, or contractility of their subordinate muscles, the positive pole must be applied to the former, and the negative to the latter. I need scarcely suggest, that to make the above experiments analogous to the condition of a warm-blooded animal, apparently dead, the frog must have its excessive voltaic sensibility considerably blunted, and brought near the standard of the latter, before beginning the experiments. Otherwise that animal electroscope, incomparably more delicate than the gold leaf condenser, will give very decided convulsions with either pole.

At the conclusion of the article *Caloric*, I have taken the liberty of suggesting some simple and ready methods of supplying warmth to the body of a drowned person.

GAMBOGE is a concrete vegetable juice, the produce of two trees, both called by the Indians caracapulli (gambogia gutta, Lin.), and is partly of a gummy and partly of a resinous nature. It is brought to us either in the form of orbicular masses, or of cylindrical rolls of various sizes; and is of a dense, compact, and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja, and Cambogia; and hence it has obtained its name of cambadium, cambogium, gambogium.

It is a very rough and strong purge; it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet, as it is said, without griping. The dose is from two to four grains as a cathartic; from four to eight grains prove emetic and purgative. The roughness of its operation is diminished by giving it in a liquid form sufficiently diluted.

This gum resin is soluble both in water and in alcohol. Alkaline solutions possess a deep red colour, and pass the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron-yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as dragon's blood sometimes is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterwards to be heated to make the colour penetrate.

It is chiefly used as a pigment in water colours, but does not stand.

According to M. Braconnot, it consists in 100 parts of 20 gum and 80 resin. *Ann. de Chim. t.* 68. *p.* 36.

GANGUE. The stones which fill the cavities that form the veins of metals are called the gangue, or matrix of the ore.

GARNET. Professor Jameson divides this mineral genus into 3 species, the *pyramidal* garnet, *dodecahedral* garnet, and *prismatic* garnet.

I. Pyramidal contains 3 sub-species, Vesuvian, Egeran, and Gehlenite, which see.

II.—*Dodecahedral* garnet contains 9 subspecies. 1. Pyreneite. 2. Grossulare. 3. Melanite. 4. Pyrope. 5. Garnet. 6. Allochroite. 7. Colophonite. 8. Cinnamon-stone. 9. Helvin.

III.—Prismatic garnet; the grenatite.

We shall treat here only of the garnet, proper. Of this sub-species we have two kinds, the precious and common.

Precious or noble garnet. Colours dark red, falling into blue. Seldom massive, sometimes disseminated, most commonly in roundish grains, and crystallized. 1. In the rhomboidal dodecahedron, which is the primitive form; 2. Ditto truncated on all the edges; 3. Acute double eight-sided pyramid; and 4. Rectangular four-sided prism. The surface of the grains is generally rough, uneven, or granulated; that of the crystals is always smooth. Lustre externally glistening; internally shining, bordering on splendent. Fracture conchoidal. Sometimes it occurs in lamellar distinct concretions. Transparent or translucent. Refracts single. Scratches quartz, but not topaz. Brittle. Rather difficultly frangible. Sp. g. 4·0 to 4.2 Its constituents are, silica, 39.66, alumina 19.66, black oxide of iron 39.68, oxide of manganese 1.80.—*Berzelius.* Before the blowpipe it fuses into a black enamel, or scoria. It occurs imbedded in primitive rocks and primitive metalliferous beds. It is found in various northern counties in Scotland; in Norway, Lapland, Sweden, Saxony, France, &c. It is cut for ringstones. Coarse garnets are used as emery for polishing metals. The following vitreous composition imitates the garnet very closely:

Purest white glass, 2 ounces
Glass of antimony, 1 ounce
Powder of Cassius, 1 grain
Manganese, 1 grain.—*Jameson.*

The garnets of Pegu are most highly valued.

Common garnet. Brown and green are its most common colours. Massive, but never in grains or angular pieces. Sometimes crystallized, and possesses all the forms of the precious garnet. Lustre shining or glistening. Fracture fine-grained, uneven. More or less translucent; the black kind nearly opaque. It is a little softer than precious garnet. Rather difficultly frangible. Sp. gr. 3.7. Before the blowpipe it melts more easily than precious garnet. Its constituents are 38 silica, 20.6 alumina, 31.6 lime, 10.5 iron.—*Vauquelin.* It occurs massive or crystallized in drusy cavities, in beds, in mica-slate, in clay-slate, chlorite-slate and primitive trap. It is found at Kilranelagh and Donegal in Ireland; at Arendal and Drammen in Norway, and in many other countries. On account of its easy fusibility and richness in iron, it is frequently employed as a flux in smelting rich iron ores. It is sometimes used instead of emery by lapidaries. —*Jameson*.

GARNET (RESINOUS). The mineral called *Colophonite*.

GARNET-BLENDE, OR ZINC-BLENDE. A sulphuret of zinc.

GAS. This name is given to all permanently elastic fluids, simple or compound, except the atmosphere, to which the term Air is appropriated.

The solid state is that in which, by the predominance of the attractive forces, the particles are condensed into a coherent aggregate; the gaseous state is that in which the repulsive forces have acquired the ascendency over the attractive; and the liquid condition represents the equilibrium of these two powers. Vapours are elastic fluids, which have no permanence; since a moderate reduction of temperature causes them to assume the liquid or solid aggregation.

Cohesive attraction among homogeneous particles is the great antagonist to chemical affinity, the attraction of composition, the force which tends to bring into intimate union heterogeneous particles. Hence the juxtaposition of two solids, of a solid and a liquid, or even of two liquids, may never determine their chemical combination, however strong their reciprocal affinity shall be.

In the case of two liquids, or a liquid and a solid, mere juxtaposition requires that the denser body be undermost, and that no disengagement of gas, or external vibration, agitate the surfaces in contact. Hence those world framers, who ascribe the saltness of the sea to supposed beds of rock salt at its bottom, have still the phenomenon of the strong impregnation of the surface to explain; for the profound tranquillity which is known to reign at very moderate depths in this mighty mass, would for ever prevent the diffusion of the saturated brine below, among the light waters above. Or if this tranquillity be disputed, then progressive density from above downwards should be found, and continually increasing impregnation. Now none of these results has occurred. But with gases in contact, there is no obstacle, from cohesive attraction, to the exertion of their reciprocal affinities. Hence, however feeble these may be, they never fail, sooner or later, to cause an intimate mixture of different gases, in which the ultimate particles approach within the limit corresponding to their reciprocal action. The difference of density may delay, but cannot prevent, uniform diffusion Thus we see that known powers can account for the phenomena. There is no need therefore of having recourse to the curious hypothesis of Mr. Dalton, that one gas is a neutral unresisting void with regard to another, into which it will rush by its innate expansive force. But of this notion sufficient notice has been taken in the article AIR (ATMOSPHERIC).

The principle of gaseous combination, first broached in the neglected treatise of Mr. Higgins, but since developed with consummate sagacity from the original researches of M. Gay Lussac, has thrown a new light on pneumatic chemistry, which has been reflected into all its mysterious departments of animal and vegetable analysis. Having given the details under the article *Equivalents* (*Chemical*), we shall merely state in this place, that the combinations of gaseous bodies are always effected in simple ratios of the volumes, so that if we represent one of the terms by unity, or 1, the other is 1, 2, or at most 3. Thus ammoniacal gas neutralizes exactly a volume equal to its own, of the gaseous acids. It is hence probable, that if the alkalis and acids were in the elastic state, they would all combine, each in equal volume with another, to produce neutral salts. The capacity of saturation of the acids and alkalis, measured by volumes, would then be the same; and perhaps this would be the best manner of estimation. In the following tables of gaseous combination, bodies naturally in the solid state, like sulphur, carbon, and iodine, will be referred to their gaseous densities, or the bulks which they occupy relative to their weights, when diffused by a chemical combination among the particles of a permanently elastic fluid. This view of the subject, first introduced by M. Gay Lussac, and happily exemplified in his excellent memoir on iodine, will simplify our representation of many compounds. Finally, the apparent contractions or condensations of volume, which gases suffer by their reciprocal affinity, have also simple ratios with the volume of one of them; a property peculiar to gaseous bodies. We shall distribute under the following heads our general observations on gases. 1. Tabular views of the densities and combining ratios of the gases. 2. A description of their general habitudes with solids and liquids. 3. An account of the principal modes of analyzing gaseous mixtures. 4. Of gasometry, or the measurement of the density and volume of gases.

I. We are indebted to Dr. Prout for an able memoir on the relation between the specific gravities of bodies in their gaseous state, and the weights of their atoms, or prime equivalents, inserted in the sixth volume of the Annals of Philosophy. His observations are founded on M. Gay Lussac's doctrine of volumes. Dr. Prout considers atmospheric air as a chemical compound, constituted by bulk of four volumes of azote and one of oxygen; and reckoning the atom of oxygen as 10, and that of azote as 17·5, it will be found to consist of one atom of oxygen, and two atoms of azote, or per cent. of oxygen 22·22
Azote 77·77
Though almost all experiments have hitherto led us to regard the atmosphere as containing 21 volumes in the 100 of oxygen, we must,

in this view, ascribe the excess of one per cent. to an error of observation. Now, it is not impossible, that in the explosive eudiometer with hydrogen over mercury, or in the nitrous gas eudiometer over water, one per cent. of azote may be pretty uniformly condensed.

Calling the prime equivalent of oxygen 1·000, and that of azote 1·75, as deduced both from nitric acid and ammonia, we may easily calculate the specific gravities of these two gaseous elements of the atmospheric compound, itself being represented in sp. gr. by 1·00, and in the relative *weights* of its constituents, by $1{\cdot}00 + \overline{1{\cdot}75 \times 2}$; or $22{\cdot}22 + 77{\cdot}77$.

The ancient problem of Archimedes, for determining the fraud of the goldsmith in making king Hiero's crown, which is so important in chemistry for computing the mean density of a compound, the specific gravities of whose two constituents are given; and for thence enabling us, by comparing that result with the density found by experiment, to discover the change of volume due to the chemical action, is of peculiar value in pneumatic investigations. It will enable us to solve, without difficulty, the two following problems:—

1st, Having given the specific gravity of a mixed gas, and the specific gravities of its two constituent gases, to determine the volume, and consequently the quantity, of each present in the mixture.

2d, Having given the specific gravity of a mixed gas, and the proportions by weight and volume of its constituents, to determine the specific gravities of each of its constituents. In both cases, no chemical condensation or expansion is supposed, and only two gases are concerned.

1st, Let d be the sp. gr. of the denser gas;
l of the lighter gas;
m mixed gas;
x the volume of the denser gas;
y of the lighter gas;
v total volume of the compound.

Then $x = \dfrac{v\,(m - l)}{(d - m) + (m - l)}$, and $y = \dfrac{v\,(d - m)}{(d - m) + (m - l)}$; from one or other of which formulæ, the volume of one or other constituent may be found; and by multiplying the volume by the specific gravity, its weight is given. The same formula is stated in words under the article *Coal Gas*.

2d, When the specific gravities of the components are sought; the specific gravity of the compound, as well as the volume and weight of each component being given, we have the following formula:—

Let x be the sp. gr. of that whose weight is a and volume m.
y be the sp. gr. of that whose weight is b and volume n.

Then $\dfrac{mx + ny}{m + n} = s$, the sp. gr. of the compound whose weight $= 1$.

But the volume of one body multiplied into its specific gravity, is to the volume of another, multiplied into its specific gravity, as the weight of the first is to that of the second, or

$$mx : ny :: a : b$$

And $m + n - ny = \dfrac{any}{b}$, if $s = 1$.

Whence $y = \dfrac{(m + n)b}{an + bn}$,

And $x = \dfrac{m + n - ny}{m}$.

Dr. Prout has very ingeniously applied this formula to the determination of the specific gravities of oxygen and azote, which are,

Oxygen,	1.1111
Azote,	0.9722

His investigation of the specific gravities of hydrogen from that of ammonia is conducted on principles still less disputable. The mean of the experimental results obtained by MM. Biot and Arago and Sir H. Davy on ammoniacal gas is 0·5902. Now it has been demonstrated, that two volumes of it are resolvable into 4 volumes of constituent gases, of which 3 volumes are hydrogen and 1 azote. Hence, if from double the specific gravity of ammonia, we subtract the specific gravity of azote, the remainder divided by 3 will be the specific gravity of hydrogen. Or, putting the same thing into an algebraic form, on the principle that the sum of the weights, divided by the sum of the volumes, gives the specific gravity of the mixture, let x be the specific gravity of hydrogen, then experiment shows, that $\dfrac{3x + 0{\cdot}9722}{2} = 0{\cdot}5902$;

Whence $x = \dfrac{\overline{2 \times 0{\cdot}5902} - 0{\cdot}9722}{3} = 0{\cdot}0694$.

The density of hydrogen therefore is to that of azote, atmospherical air, and oxygen, as 1 to 14, 1 to 14·4, and 1 to 16, respectively.

And with regard to muriatic acid gas, it is well known to result from the union of chlorine and hydrogen in equal volumes, without any condensation; therefore if we call the sp. gr. of the compound gas 1.285, and from the double of that number deduct the sp. gr. of hydrogen, we shall have the sp. gr. of chlorine $+ = \overline{1{\cdot}285 \times 2} - 0{\cdot}0694 = 2{\cdot}5006$, which may be converted into the even number 2·5 without any chance of error. See *Sect. IV.*

In the common tables of equivalent ratios, adapted to the hypothesis that water is a compound of one atom of oxygen and one of hydrogen, or of half a volume of the former and one volume of the latter, we must compute the ratios of gaseous combination, among different bodies, by multiplying the weight of their atom or their prime equivalents by half the sp. gr. of oxygen = 0·5555. If the volume and sp. gr. of hydrogen were reckoned unity, then the doctrine of volumes and prime equivalents would coincide.

General Table of Gaseous Bodies, by Dr. Ure.

Barometer 30°—Thermometer 60° F.

Names.	Sp. gr. air = 1.00.	Weight of 100 cubic inches.	Weight of prime equiv. oxygen = 1.	Constituents by volume.	Resulting volume.	Constituent prime equivalents.
Hydrogen,	0·0694	2·118	0·125			
Carbon,	0·4166	12·708	0·750			
Steam of water,	0·481	14·680	1·125	2 hyd. + 1 oxyg.		1 hyd. + 1 oxyg.
Subcarb. hydrogen,	0·5555	17·000	1·000	2 hyd. + 1 carb.	1	2 hyd. + 1 carb.
Ammonia,	0·5902	18·000	2·125	3 hyd. + 1 azote	2	3 hyd. + 1 azote
Carbonous oxide,	0·9722	29·65	1·750	2 carb. + 1 oxyg.	2	1 carb. + 1 oxyg.
Carburetted hydrogen,	0·9722	29·65	0·875	1 carb. + 1 hyd.	½	1 carb. + 1 hyd.
Azote,	0·9722	29·65	1·750			
Prussic acid,	0·9374	28·59	3·375	1 cyan. + 1 hyd.	2	1 cyan. + 1 hyd.
Atmospheric air,	1·0000	30·519	4·500	1 oxy. + 4 azote	5	1 oxyg. + 2 azote
Deutoxide of azote,	1.0416	31·77	3·750	1 oxy. + 1 azote	2	2 oxyg. + 1 azote
Oxygen,	1·1111	33·888	1·000			
Sulphur,	1·1111	33·888	2·000			
Sulphuretted hydrogen,	1·1805	36·006	2.125	1 hyd. +1 sulph.	1	1 hyd. + 1 sulph.
Protophosphd. hydrogen,	1·215	37·027	4·375	1 phos. + 3 hyd.	2	1 phos. + 3 hyd.
Muriatic acid,	1·2840	39·183	4·625	1 hyd. + 1 chlo.	2	1 hyd. + 1 chlor.
Carbonic acid,	1·5277	46·596	2·750	1 carb. + 1 oxyg.	1	1 carb. + 2 oxyg.
Protoxide of azote,	1·5277	46·596	2·750	1 oxy. + 2 azote	2	1 oxyg. + 1 azote
Alcohol vapour,	1·6133	49·20	2·875	1 ol. gas + 1 wa.	1	2 ol. gas. +1 water
Perphosphd. hydrogen,	1·771	53·710	4·250	1½ phos. +3 hyd.	2	1 phos. + 2 hyd.
Cyanogen,	1·8055	55·07	3·25	2 carb. + 1 azote	1	2 carb. + 1 azote
Chloroprussic acid,	2·1527	65·69	7·75	1 cya. + 1 chlo.	2	1 cyan. + 1 chlor.
Muriatic ether,	2·2562	67·68	5·5	1 mur. +1 ol. gas	2	1 m. ac. +1 ol. gas
Sulphurous acid,	2·222	67·77	4·000	1 oxy. +1 sulph.	1	2 oxyg. +1 sulph.
Phosphorus,	2·222	67·77	4·000			
Deutoxide of chlorine,	2·361	72·0	9·50	2 oxy. + 1 chlo.	2	1 chlor. +4 oxyg.
Fluoboric acid,	2·371	72·312	8·500			
Protoxide of chlorine,	2·44	74·42	5·50	2 oxy. + 4 chlo.	5	1 oxyg. +1 chlor.
Chlorine,	2·500	76·25	4·50			
Sulphuric ether vapour,	2·586	78·87	2.875	2 olef. + 1 wat.	1	4 olef. + 1 water
Nitrous acid,	2·638	80·48	4.75	3 oxy. + 2 azote	2	3 oxyg. + 1 azote
Sulphuret of carbon,	2·638	80·66	4·750	2 carb. +4 sulph.	2	2 sulph. + 1 carb.
Sulphuric acid,	2·777	84·72	5·000	3 oxy. + 2 sulph.	2	3 oxyg. +1 sulph.
Chlorocarbonous acid,	3·472	105·9	6·25	1 chl. +1 car. ox.	1	1 chlo. +1 car. ox.
Sal ammoniac,	3·746	114·3	6·75	2 amm. +2 mur.	1	1 am. +1 mu. acid
Nitric acid,	3·75	114·37	6·75	5 oxyg. + 2 azote	2	5 oxyg. + 1 azote
Hydriodic acid,	4·340	132·37	15·625	1 hyd. + 1 iodine	2	1 hyd. + 1 iodine
Oil of turpentine,	5·013	152·9				
Chloric acid,	5·277	160·97	9·5	5 oxyg. +2 chlo.	2	5 oxyg. +1 chlor.
Fluoborate of ammonia,	5·922	180·	10·625	2 am. + 2 fluob.	1	1 am. + 1 fluobor.
Subfluob. ammonia,	7·10	216·7	12·750	4 am. + 2 fluob.	1	2 am. + 1 fluobor.
Tritosubfluob. ammonia,	8·28	252·	14·875	6 am. + 2 fluob.	1	3 am. + 1 fluobor.
Fluosilicate of ammonia,				2 am. + 1 acid.		

In the preceding table I have endeavoured to assemble the principal features of gaseous combination. For the properties of these different gases, see the separate articles in the Dictionary.

II. Of the general habitudes of gaseous matter with solids and liquids. Mr. Dalton has written largely on these relations; but his results are so modified by speculation, that it is difficult to distinguish fact from hypothesis. Dr. Henry, however, made some good researches on the subject of this division, but they have since been so much extended and improved by M. de Saussure, that I shall take his elaborate researches for my guide. His Memoir on the absorption of the gases by different bodies, was originally read to the Geneva Society on the 16th April, 1812, and appeared in Gilbert's Annalen der Physik for July 1814, from which it was translated into the 6th volume of the Annals of Philosophy.

1. Of the absorption of unmixed gases by solid bodies.

Of all solid bodies charcoal is the most remarkable in its action on the gases. In M. de Saussure's experiments, the red-hot charcoal was plunged under mercury, and introduced, after it became cool, into the gas to be absorbed, without ever coming into contact with atmospherical air.

TABLE of the Volumes of Gases absorbed by one Volume of

GASES.	Charcoal.	Meerschaum.	Adhesive slate.	Ligniform asbestus.	Saxon hydroph.	Quartz.
Ammonia, . .	90	15	11·3	12·75	64	10
Muriatic acid, . .	85	—	—	—	17	—
Sulphurous acid, . .	65	—	—	—	7·37	—
Sulphuretted hydrogen, .	55	11·7	—	—	—	—
Nitrous oxide, . .	40	3·75	—	—	—	—
Carbonic acid, . .	35	5·26	2	1·7	1·0	0·6
Olefiant gas, . .	35	3·70	1·5	1·7	0·8	0·6
Carbonic oxide, . .	9·42	1·17	0·55	0·58	—	—
Oxygen, . . .	9·25	1·49	0·7	0·47	0·6	0·45
Azote, . . .	7·5	1·6	0·7	0·47	0·6	0·45
Oxycarburetted hydrogen from moist charcoal,	5·0	0·85	0·55	0·41	—	—
Hydrogen, . .	1·75	0·44	0·48	0·31	0·4	0·37

The absorption was not increased by allowing the charcoal to remain in contact with the gases after 24 hours; with the exception of oxygen, which goes on condensing for years, in consequence of the slow formation and absorption of carbonic acid. If the charcoal be moistened, the absorption of all those gases that have not a very strong affinity for water, is distinctly diminished. Thus boxwood charcoal, cooled under mercury, and drenched in water while under the mercury, is capable of absorbing only 15 volumes of carbonic acid gas; although, before being moistened, it could absorb 35 volumes of the same gas. Dry charcoal, saturated with any gas, gives out, on immersion in water, a quantity corresponding to the diminution of its absorbing power. During the absorption of gas by charcoal, an elevation of temperature takes place, proportional to the rapidity and amount of the absorption. The vacuum of the air-pump seems to possess the same influence as heat, in rendering charcoal capable of absorbing gaseous matter. A *transferrer* with a small jar containing a piece of charcoal was exhausted, and being then plunged into a pneumatic trough, was filled with mercury. The charcoal was next introduced into a gas, and absorbed as much of it as after having been ignited. As the rapid absorption of carbonic acid gas by charcoal can raise the thermometer 25°, so its extraction by the air-pump sinks it 7·5°.

Though charcoal possesses the highest absorbent power, yet it is common to all bodies which possess a certain degree of porosity, after they have been exposed to the action of an air-pump. Meerschaum, like charcoal, absorbs a greater bulk of rare than dense gas. Dried woods, linen threads, and silks, also absorb the gases. Of ammonia, hazel absorbs 100 volumes, mulberry 88, linen thread 68, silk 78; of carbonic acid, in the above order, 1·1, 0·46, 0·62, 1·1; of this gas, fir absorbed 1·1, and wool 1·7.

The rate of absorption of different gases appears to be the same, in all bodies of similar chemical properties. All the varieties of asbestus condense more carbonic acid gas than oxygen gas; but woods condense more hydrogen than azote. Yet the condensations themselves in different kinds of asbestus, or wood, or charcoal, are very far from being equal. Ligniform asbestus absorbs a greater volume of carbonic acid gas than rock cork; so does hydrophane than the swimming quartz of St. Ouen, and the quartz of Vauvert; and the absorption of gases by boxwood charcoal is much greater than by fir charcoal. These differences are not in the least altered, if, instead of equal volumes, equal weights of charcoal be employed. It is curious that a piece of solid charcoal absorbs 7½ volumes, and the same reduced into fine powder absorbs only 3 volumes. The absorbing power of most kinds of charcoal increases as the specific gravity increases; and it is obvious, that the pores must become smaller and narrower with the increase of density. Charcoal from cork, of a specific gravity not exceeding 0·1, absorbed no sensible quantity of atmospheric air. Charcoal from fir, sp. gr. 0·4, absorbed 4¼ times its volume of atmospherical air; that from boxwood, sp. gr. 0·6, absorbed 7½ of air; and pit-coal of vegetable origin from Russiberg, sp. gr. 1·326, absorbed 10½ times its volume of air. But, as the density augments, we arrive at a limit, when the pores become too small to allow gases to enter. Thus, the *black-lead* of Cumberland, containing 0·96 of carbon, sp. gr. 2·17, produces no alteration on atmospherical air. But this correspondence between the power of absorbing and the specific gravity, is only accidental. Accurate experiments show remarkable deviations from this rule. The different kinds of charcoal, whether of similar or dissimilar sp. gravities, always differ from each other in their organization. They cannot be considered as resembling a sponge, whose pores and density may be modified by pressure.

On the whole it appears, that the property of condensing gases, possessed by some solids, is, within certain limits, in the inverse ratio of the internal diameter of the pores of the absorbing bodies. But besides the porosity, there are other two circumstances which must be attended to in these absorptions; 1. The different affinities which exist between the gases and the solid bodies; and, 2. The power of expansion of the gases, or the opposition they make to their condensation, at different degrees of heat and atmospherical pressure.

The experiments hitherto described relate to the absorption of a single gas, not mixed with any other. But, when a piece of charcoal saturated with either oxygen, hydrogen, azote, or carbonic acid, is put into another gas, it allows a portion of the first to escape, in order to absorb into its pores a portion of the second gas. The volume of gas thus expelled from charcoal by another gas, varies according to the proportion in which both gases exist in the unabsorbed residue. The quantity expelled is greater, the greater the excess of the expelling gas. Yet it is not possible, in close vessels, to expel the whole of one gas out of charcoal, by means of another; a small quantity always remains in the charcoal.

Two gases, united by absorption in charcoal, often experience a greater condensation than each would in a separate state. For example, the presence of oxygen gas in charcoal facilitates the condensation of hydrogen gas; the presence of carbonic acid gas, or of azote, facilitates the condensation of oxygen gas; and that of hydrogen the condensation of azote. Yet this effect does not take place in all cases, with the four gases now mentioned; for the presence of azote in charcoal does not promote the absorption of carbonic acid gas. When the absorption of one of the four named gases has been facilitated by another of them, no perceptible combination between the two takes place, at least within the interval of some days. So, for example, notwithstanding the assertion of Rouppe and Van Noorden, no separation of water appears, when charcoal saturated with hydrogen at the common temperatures is put into oxygen gas; or when the experiment it reversed. Nor has azote and hydrogen been united in this way into ammonia, or azote and oxygen into nitric acid.

2. Absorption of *gases* by *liquids*.

"That all gases are absorbed by liquids," says M. de Saussure, "and that most of them are again separated by heat, or the diminution of external pressure, has been long known. We now possess accurate results respecting the rate of this absorption. For a set of careful and regular experiments on this subject, we are indebted to Dr. Henry of Manchester. Mr. Dalton has a little altered some of these results; and, by means of them, has contrived a theory which not only explains the absorption of gases by water, but by all other liquids; but it is in opposition to most of the results which I have obtained by means of solid porous bodies."

The following table exhibits the volumes of the different gases absorbed according to the accurate experiments of Saussure, by 100 volumes of—

GASES.	Water.	Alcohol sp. gr. 0.84.	Naphtha sp. gr. 0.784.	Oil of lav. sp. gr. 0.88	Olive oil.	Satur. solution mur. pot.
Sulphurous acid . .	4378	11577				
Sulphuretted hydrogen, .	253	606				
Carbonic acid, . .	106	186	169	191	151	61
Nitrous oxide, . .	76	153	254	275	150	21
Olefiant gas, . .	15·3	127	261	209	122	10
Oxygen gas, . .	6·5	16·25	—	—	—	—
Carbonous oxide, . .	6·2	14·50	20	15·6	14·2	5·2
Oxycarburetted hydrogen	5·1	7·0				
Hydrogen, . . .	4·6	5·1				
Azote	4·1	4·2				

The above liquids were previously freed from air, as completely as possible, by long and violent boiling. But those which would have been altered or dissipated by the application of such a heat, as oils, and some saline solutions, were freed from air by means of the air-pump. To produce a speedy and complete absorption, a large quantity of those gases which are absorbed only in small quantity by liquids, as azote, oxygen, and hydrogen, was put, with a small quantity of the liquid, into a flask, which was furnished with an excellent ground stopper. The flask was agitated for a quarter of an hour. This method is difficult, and requires much attention. With respect to all the gases of which the liquid absorbs more than 1-7th of its bulk, M. de Saussure proceeded in the following manner:—He placed them over mercury, in a tube fully 1½ inches internal diameter, and let up a column of the absorbing liquid, from about 1¾ to 2¼ inches long. The absorption was promoted by agitation, and its quantity was not determined till the gas and the liquid had been in contact for several days.

A hundred volumes of water absorb about five volumes of atmospherical air, when the mass of air is very great, in comparison of that of the water.

"From these experiments," says M. de Saussure, "it appears, contrary to Dalton's assertion, that the absorption of gases, by different liquids, not glutinous, as water and alcohol, is very far from being similar. The alcohol, as we see, often absorbs twice as much of them as the water does. In gases which are absorbed in small quantities, this difference is not so striking, because, with respect to them, the absorptions of the alcohol can be less accurately determined, on account of the air which still remains in it, after being boiled.

"These experiments agree no better with the law which Dalton thinks he has ascertained in the absorption of different gases by one and the same liquid; for I find too great a difference between the quantity of carbonic acid, sulphuretted hydrogen, and nitrous oxide gases, absorbed by the same liquids (which Dalton considers as completely equal), to be able to ascribe it to errors in the experiments."

3. Of the influence of chemical affinity on the absorption of the gases.

If such an influence did not exist, the gases would be absorbed by all liquids in the same order. Table of the volumes of gases absorbed by 100 volumes of

Names of gases.	Naph. sp. gr. 0.784.	Oil of lav. sp. gr. 0.88.	Olive oil.	Solution mur. pot.
Olefiant gas,	261	209	122	10
Nitrous oxide,	254	275	150	21
Carbonic acid,	169	191	151	61
Carbo. oxide,	20	15·6	14·2	5·2

"It follows," says M. de Saussure, "from these experiments, that in liquids, as well as in solid bodies, great differences take place in the order in which gases are absorbed by them, and that, in consequence, these absorptions are always owing to the influence of chemical affinity. Solid bodies appear, under the same circumstances, to produce a greater condensation of all gases, in contact with which they are placed, than liquid bodies do. I have met with no liquid which absorbs so great a volume of carbonic acid, olefiant gas, azotic gas, carbonous oxide, and nitrous oxide, as charcoal and meerschaum do. The difference is probably owing to this circumstance, that liquids, in consequence of the great mobility of their parts, cannot compress the gases so strongly as is necessary for greater condensation, certain cases excepted, when very powerful chemical affinities come to their assistance; as, for example, the affinity of ammonia and muriatic acid for water. Only in these rare cases do liquids condense a greater quantity of gases than solid bodies. According to Thomson, water in the mean temperature of the atmosphere absorbs 516 times its bulk of muriatic acid gas, and 780 times its bulk of ammoniacal gas." In the articles *muriatic acid* and *ammonia* in the first edition of this Dictionary, I have shown these determinations of Dr. Thomson to be erroneous.

4. Influence of the viscidity, and the specific gravity of liquids on their absorption of gases. Carbonic acid gas was placed in contact with one volume of the different liquids. The temperature in all the experiments was 62·5°.

LIQUIDS.	Sp. gr.	Volume of car. acid gas absorbed.	100 parts of the solution, contain
Alcohol,	0·803	2·6	
Sulph. ether,	0·727	2·17	
Oil of lavender,	0·880	1·91	
Oil of thyme,	0·890	1·88	
Spirit of wine,	0·840	1·87	
Rectified naphtha,	0·784	1·69	
Oil of turpentine,	0·860	1·66	
Linseed oil,	0·940	1·56	
Olive oil,	0·915	1·51	
Water,	1·000	1·06	
Sal ammoniac,	1·078	0·75	27.53 crystals, sat. sol.
Gum arabic,	1·092	0·75	25. gum,
Sugar,	1·104	0·72	25. sugar,
Alum,	1·047	0·70	9·14 cry. al. sat. sol.
Sulphate of potash,	1·077	0·62	9·42 c. s. sat. sol.
Muriate of potash,	1·168	0·61	26·0 c. s. sat. sol.
Sulphate of soda,	1·105	0·58	11·14 dry salt, sat. sol.
Nitre,	1·139	0·57	20·6 sat. sol.
Nitrate of soda,	1·206	0·45	20.4 sat. sol.
Sulphuric acid,	1·840	0·45	
Tartaric acid,	1·285	0·41	53·37 c. acid, sat. sol.
Common salt,	1·212	0·329	29. s. sat. sol.
Muriate of lime,	1·402	0·261	40·2 ignited salt, sat. sol.

Though the influence of the viscidity of a liquid be small with regard to the amount of the absorption, yet it increases the time necessary for the condensation of the gas. In general, the lightest liquids possess the greatest power of absorbing gases; with the exception of those cases where peculiar affinities interfere.

5. Influence of the barometrical pressure on the absorption of gases by liquids.

M. de Saussure shows, that in liquids the quantities of gases absorbed are as the compressions; while in solid bodies, on the contrary, as the gases become less dense, the absorption seems to increase. Dr. Henry had previously demonstrated, that the quantity of carbonic acid taken up by water, is proportional to the compressing force; a fact long ago well known and applied by Schweppe, Paul, and other manufacturers of aerated alkaline waters.

6. Simultaneous absorption of several gases by water.

M. de Saussure thinks it probable, that the absorption of the different gases at the same time by liquids, is analogous to what he observed with respect to solid bodies. Henry, Dalton, Van Humboldt, and Gay Lussac, had already remarked, that water saturated with one gas, allows a portion of that gas to escape, as soon as it comes in contact with another gas. "It is indeed evident, according to Dalton's theory," says M. de Saussure, "that two gases absorbed into a liquid, should really occupy always the same room as they would occupy, if each of them had been absorbed singly, at the degree of density which it has in the mixture." To obtain results on this subject, approaching to accuracy, he was obliged to make mixtures of carbonic acid with oxygen, hydrogen, and azotic gases; for the last three gases are absorbed by water in so small a proportion, that the different condensations which take place cannot be confounded with errors in the experiments.

1. Water, and a mixture of *equal* measures of carbonic acid and hydrogen gas.

He brought 100 measures of water, at the temperature of 62½°, in contact with 434 measures of equal volumes of carbonic acid and hydrogen. The absorption amounted to 47·5 volumes, of which 44 were carbonic acid, and 3·5 hydrogen. If we compare the space which the absorbed gases occupy in the water, with that which they would occupy, according to the preceding table of absorption of unmixed gases, we find that the presence of one of the gases has favoured the absorption of the other, as far as the relative space goes, which each would occupy separately in the water.

2. Water, and a mixture of *equal* parts of carbonic acid and oxygen gas.

100 volumes of water at 62½° absorbed from 390 volumes of this mixture 52·1 volumes, of which 47·1 volumes were carbonic acid, and 5 volumes oxygen gas. Here also the condensation is greater than when the gases are separate.

3. Water and a mixture of carbonic acid gas and azote.

100 volumes of water absorbed from 357·6 volumes of this mixture, at the above temperature, 47·2 volumes, of which 43·9 volumes were carbonic acid, and 3.3 azote.

The results of these experiments, as we perceive, agree completely with each other; but *none* of them corresponds with Dalton's theory, according to which, the volume of carbonic acid absorbed should be just one-half of that of the absorbing liquid; and likewise the volumes of the other gases absorbed should be much smaller than M. de Saussure found them actually to be. A mixture of oxygen and hydrogen gases, in the proportions for forming water, by agitation with that liquid, was absorbed in the proportion of 5¼ volumes to 100 volumes of the liquid. In an appendix, M. de Saussure describes minutely the judicious precautions he took to ensure precision of result; which leave little doubt of the accuracy of his experiments, and the justness of his conclusions. They are as fatal to Mr. Dalton's mechanical fictions concerning the relation of liquids and gases, as MM. Dulong and Petit's recent researches have been to his geometrical ideas on the phenomena of heat.

III. Of Gaseous Analysis.

This department of chemistry, whose great importance was first shown by Cavendish, Priestley, and Berthollet, has lately acquired new value in consequence of M. Gay Lussac's doctrine of volumes, his determination of the specific gravities of vapours, and sagacious application of both principles to the development of many combinations hitherto intricate and inexplicable.

Let us first take a general view of the characters of the different gases. Some of them are coloured, others diffuse white vapours in the air; some relume a taper, provided a point of its wick remains ignited; others are acid, and redden tincture of litmus; one set have no smell, or but a faint one; a second set are very soluble in water; a third are soluble in alkaline solutions; and a fourth are themselves alkaline. Some gases possess several of these characters at once.

1. The *coloured gases* are nitrous acid, chlorine, the protoxide and deutoxide of chlorine. The first is red, the rest yellowish-green, or yellowish.

2. Gases producing *white vapours* in the air. Muriatic acid, fluoboric, fluosilicic, and hydriodic.

3. Gases *inflammable* in air by contact of the lighted taper. Hydrogen, subcarburetted and carburetted hydrogen, subphosphuretted and phosphuretted hydrogen, sulphuretted hydrogen, arsenuretted hydrogen, telluretted hydrogen, potassuretted hydrogen, carbonous oxide, prussine or cyanogen.

4. Gases which *rekindle* the expiring taper. Oxygen, protoxide of azote, nitrous acid, and the oxides of chlorine.

5. *Acid* gases, which *redden* litmus. Nitrous, sulphurous, muriatic, fluoboric, hydriodic, fluosilicic, chlorocarbonous, and carbonic acid; the oxides of chlorine, sulphuretted hydrogen, telluretted hydrogen, and prussine.

6. Gases *destitute of smell*, or possessing but a feeble one. Oxygen, azote, hydrogen, subcarburetted and carburetted hydrogen, carbonic acid, protoxide of azote.

7. The smell of all the others is insupportable, and frequently characteristic.

8. Gases very *soluble in water*, namely, of which water dissolves more than 30 times its volume, at ordinary pressure and temperature. Fluoric acid, muriatic, fluosilicic, nitrous, sulphurous, and ammonia.

9. Gases *soluble* in *alkaline* solutions. Acids, nitrous, sulphurous, muriatic, fluoboric, hydriodic, fluosilicic, chlorine, carbonic, chlorocarbonous; and the two oxides of chlorine, sulphuretted hydrogen, telluretted hydrogen, and ammonia.

10. *Alkaline* gases. Ammonia and potassuretted hydrogen.

Such is a general outline of the characteristics of the gases. *The great problem which now presents itself is, to determine by experiments the nature of any single gas, or gaseous mixture, which may come before us.*

I.

We first fill a little glass tube with it, and expose it to the action of a lighted taper. If it inflames, it is one of the 11 above enumerated, and must be discriminated by the following methods.

1. If it takes fire spontaneously on contact with air, producing a very acid matter, it is *phosphuretted hydrogen*. Subphosphuretted hydrogen, or the bihydroguret of phosphorus, does not spontaneously inflame.

2. If water be capable of decomposing it, and transforming it suddenly into hydrogen gas and alkali, which we can easily ascertain by transferring the test tube, filled with it, from the mercurial trough, to a glass containing water, it is *potassuretted hydrogen*. I found in my experiments on the production of potassium, by passing pure potash over ignited iron turnings, of which some account was published in 1809, that potassuretted hydrogen spontaneously inflamed. M. Sementini has made the same observation.

3. If it has a nauseous odour, is insoluble in water, leaves on the sides of the test tube in which we burn it a chestnut-brown deposite, like hydruret of arsenic, and if, after agitation with the quarter of its volume of aqueous chlorine, a liquid is formed, from which sulphuretted hydrogen precipitates yellow flocculi, it is *arsenuretted hydrogen gas*.

4. If it has a strong smell of garlic or phosphorus, if it does not inflame spontaneously, if the product of its combustion strongly reddens litmus, and if, on agitation with an excess of aqueous chlorine, a liquor results, which, after evaporation, leaves a very sour syrupy residuum, it is *subphosphuretted hydrogen*.

5. If it has no smell, or but a faint one, and if it be capable of condensing one-half its volume of oxygen in the explosive eudiometer, it is *hydrogen*.

6. If it has a faint smell, be capable of condensing in the explosive eudiometer one-half of its volume of oxygen, and of producing a volume of carbonic acid equal to its own, which is ascertained by absorbing it with aqueous potash, it is *carbonous oxide*.

7. If it has a faint smell, if one of the products of combustion is carbonic acid, and if the quantity of oxygen which it condenses by the explosive eudiometer, corresponds to twice or thrice its volume, then it is either *subcarburetted* or *carburetted hydrogen*.

8. If it diffuses the odour of rotten eggs, if it blackens solutions of lead, if it leaves a deposite of sulphur, when we burn it, in the test tube, and if it be absorbable by potash, it is *sulphuretted hydrogen*.

9. If it has a fetid odour, approaching to that of sulphuretted hydrogen, if it is absorbable by potash, if it is soluble in water, if it forms with it a liquid, which, on exposure to air, lets fall a brown pulverulent hydruret of tellurium; and lastly, if on agitation with an excess of aqueous chlorine, there results a muriate of tellurium, yielding a white precipitate with alkalis, and a black with the hydrosulphurets, it is *telluretted hydrogen*.

10. *Prussine* is known by its offensive and very peculiar smell, and its burning with a purple flame.

II.

If the gas be non-inflammable, but absorbable by an alkaline solution, it will be one of the 13 following: muriatic acid, fluoboric, fluosilicic, hydriodic, sulphurous, nitrous, chlorocarbonous, carbonic; or chlorine, the oxides of chlorine, prussine, or ammonia. The first four, being the only gases which produce white vapours with atmospheric air, from their strong affinity for water, are thus easily distinguishable from all others. The *fluosilicic gas* is recognised by the separation of silica, in white flocculi, by means of water; and *hydriodic gas*, because chlorine renders it violet, with the precipitation of iodine.

Muriatic acid gas, from its forming with solution of silver a white precipitate insoluble in acids, but very soluble in ammonia, and from its yielding with oxide of manganese a portion of chlorine. *Fluoboric gas*, by the very dense vapours which it exhales, and by its instantly blackening paper plunged into it. *Nitrous acid gas* is distinguished by its red colour. *Protoxide of chlorine*, because it is of a lively greenish-yellow hue, because it exercises no action on mercury at ordinary temperatures, and because, on bringing ignited iron or glass in contact with it, it is decomposed with explosion into oxygen and chlorine.

Deutoxide of chlorine is of a still brighter yellowish-green than the preceding, and has a peculiar aromatic smell. It does not redden, but blanches vegetable blues. At 212° it explodes, evolving oxygen and chlorine. *Chlorine* is distinguished by its fainter yellowish-green colour, by its suffering no change on being heated, by its destroying colours, and by its rapid combination with mercury at common temperatures. *Sulphurous acid* by its smell of burning sulphur. *Ammonia* by its odour, alkaline properties, and the dense white vapours it forms with gaseous acids. *Chlorocarbonous gas* is converted by a very small quantity of water into aqueous muriatic acid, and carbonic acid, which rests above. Zinc or antimony, aided by heat, resolves it into carbonous oxide gas, while a solid metallic chloride is formed. With the oxides of the same metals it forms chlorides, and carbonic acid, while in each case the quantity of gaseous oxide of carbon, and carbonic acid disengaged, is equal to the volume of chlorocarbonous gas operated on. *Carbonic acid gas* is colourless, and void of smell, while all the other gases absorbable by the alkalis have a strong odour. It hardly reddens even very dilute tincture of litmus; it gives a white cloud with lime water, from which a precipitate falls, soluble with effervescence in vinegar.

III.

If, finally, the gas be neither inflammable, nor capable of being absorbed by a solution of potash, it will be oxygen, azote, protoxide of azote, or deutoxide of azote. *Oxygen* can be mistaken only for the protoxide of azote. The property it possesses of rekindling the expiring wick of a taper, distinguishes it from the two other gases. They are moreover characterized, 1st, Because oxygen is void of taste, and capable of condensing in the explosive eudiometer twice its volume of hydrogen gas; the *protoxide of azote*, because it has a sweet taste, is soluble in a little less than half its volume of cold water, and because when detonated with its own volume of hydrogen, we obtain a residuum, containing much azote. The two other gases are distinguished thus: *Deutoxide of azote* is colourless, and when placed in contact with atmospherical air or oxygen, it becomes red, passing to the state of nitrous acid vapour. *Azote* is void of colour, smell, and taste, extinguishes combustibles, experiences no change on contact with air, and produces no cloud with lime water.

common problem in gaseous analysis, for which no *direct* problem has I believe, been yet offered. Allusion has been made to it in treating of coal gas, and the plan pointed out in a popular way.

Analytical problem.—In a mixture constituted like purified coal gas, of three inflammable gases, such as olefiant gas, carburetted hydrogen, and carbonous oxide, inseparable by ordinary chemical means, to determine directly the quantity of each.

1. By the rule given at the commencement of the present article *Gas*, find from the specific gravity of the mixed gases the proportion of the light carburetted hydrogen. The remainder is the bulk of the other two gases. Detonate 100 measures of the mixed gas with excess of oxygen in an explosive eudiometer. Observe the change of volume, and ascertain the expenditure of oxygen. Of the oxygen consumed, allow two volumes for every volume of light carburetted hydrogen, sp. gr. 0.555, previously found, by the hydrostatic rule, to be present. The remaining volumes of oxygen have gone to the combustion of heavy carburetted hydrogen, or olefiant gas and carbonous oxide. Then,

Let m = measure of oxygen equivalent to 1 of first gas,
n = do. do. to 1 of second gas,
p = measures of oxygen actually consumed,
100 or s = volume of mixture of these two gases,
x = volume of first gas,
$s - x$ = volume of second gas,

$$x = \frac{p - ns}{m - n}.$$

EXAMPLES.

1*st*, 100 measures of purified coal gas were found, by the hydrostatic problem, to contain 76 of subcarburetted hydrogen; and exploded in the eudiometer they were found to consume 187 cubic inches of oxygen. By condensing with potash the carbonic acid formed, we learn the volume of residuary oxygen. But the solution of the problem is otherwise independent of the quantity of carbonic acid generated in the present experiment. We see from the table of the gases, that 1 volume of olefiant gas is equivalent to 3 of oxygen; and 1 volume carbonous oxide to one-half volume oxygen. Therefore, deducting for the 76 of subcarbonate, 152 measures of oxygen, the remaining 35 have gone to the 24 measures of the two denser gases. Hence

Olefiant gas, or $x = 35\ \frac{(0{\cdot}5 \times 24)}{2{\cdot}5} = 9{\cdot}2$

gen: What is the proportion of olefiant gas?

x or olefiant $= 236\ \frac{(0{\cdot}5 \times 100)}{2{\cdot}5} = 74{\cdot}4$,

consequently 25·6 are carbonous oxide.

This problem is applicable to every mixture of two inflammable gases. The hydrostatic problem I have been accustomed for years to apply to mixtures of two gases, whose specific gravities are considerably different, as carbonic acid and atmospheric air, and with a delicate balance, and globe containing 100 cubic inches, it gives a good accordance with chemical experiment.

I employed this method for verification, in examining the air extracted from the lungs of the criminal's dead body, galvanized at Glasgow in Nov. 1818.

Generally, if we wish to get an approximate knowledge of the proportion of two gases in a mixture, we may adopt the following plan. Poise the exhausted globe or flask at one arm of a delicate balance. Then connect its stopcock with the gasometer, bladder, or jar, containing the gaseous mixture. Introduce an unmeasured quantity, great or small, relative to the capacity of the globe; for it is not necessary that the density of the air in the globe should be equal to that of the atmosphere. In fact, it may happen, that the whole quantity of the gaseous mixture may not be equal to more than one-third, one-half, or three-fourths of the capacity of the globe. For instance, in the case of the criminal, I took a globe, capable of receiving greatly more than the aërial contents of his lungs. An unknown quantity of the mixed gases being now in the globe, we suspend it at the balance, and note the increase of weight. We then open the stop-cock, and allow the atmosphere to enter, till an equilibrium of pressure ensues. The additional weight occasioned by the atmospheric air must be converted into bulk, at the rate of 30.519 gr. for 100 cubic inches. Deducting this bulk from the known capacity of our globe or flask, leaves a remainder, which is the volume of the gaseous mixture first introduced: knowing its weight and volume, we infer its specific gravity; and from its specific gravity, by the hydrostatic problem, we deduce the proportion of each gas in the mixture.

IV.

Of the method of determining the specific gravity of gases, and of the modification of their volume from variation of pressure and temperature.—The specific gravity of a gas is the weight of a certain volume of it, compared to the same volume of air or water. Air is now assumed as the standard for gases, as water is for liquids; and the same hydrostatic method proceed thus :—We poise the globe at the end of a balance, with its stop-cock open: we next exhaust it, and weigh it in that state. The difference of the two weighings is the apparent weight of the volume of atmospheric air withdrawn from it. We verify that first estimate, by opening the stop-cock, and noting the increase of weight occasioned by the ingress of the air. Having again exhausted, exactly to the same degree, by the mercurial gauge, as before, we poise. This gives us, for the third time, the weight of air contained by the globe. The mean of the three trials is to be taken. We now attach it, by the screw of the stop-cock, to a gasometer or jar, containing gas desiccated by muriate of lime over mercury, and opening the communication, allow the air to enter till an equilibrium of pressure with the atmosphere is established. In this stage of the operation, we must avoid grasping the globe with our hands, and we must see that the mercury in the inside and outside of the jar stands truly on a level. On re-suspending the globe at the balance, we find the weight of the included gas, which being divided by the weight of the air formerly determined, gives a quotient, which is the specific gravity of the gas in question. When the utmost precision is required, we should again exhaust the globe, again poise it, and filling it with the gas, again ascertain its sp. gravity under the bulk of the globe. Even a third repetition is sometimes necessary to secure final accuracy. We should always terminate the operations by a new weighing of the atmospheric air, lest its temperature or pressure may have changed during the course of the experiments. It is obvious, that this method differs in no respect from that practised long ago by the Hon. Robert Boyle, and by Sir Charles Blagden, (See ALCOHOL), with liquids, and is that which, I suppose, every public teacher of physics, like myself, explains and exhibits annually to his pupils. With regard to liquids, it is necessary to bring them to a standard temperature, which in this country is 60° F. But, as the comparison of gases with air is always made at the instant, our only care need be, that the gas and atmosphere are in the same state as to temperature and moisture, and that the equilibrium of pressure be ensured to the gas by bringing the liquid which confines it to a level on the inside and outside of the jar.

If the gases stand over water, it is desirable to weigh them in somewhat cold weather, when the thermometer is, for example, at 40°; for then the quantity of aqueous vapour they contain is exceedingly small. Or otherwise, we should place the atmospheric air we use for the standard of comparison in the very same circumstances, over water, at 60° for instance; and then with regard to those gases whose density is greater or less than air, we shall learn, that the same bulk of different gases standing over water gives out, on being transmitted over dry muriate of lime, the same quantity of that liquid; which, for 100 cubic inches, is, by the first philosopher, 0·35 of a grain troy at 57° F., and by the second 0·236 at 54°. We shall, perhaps, not err, by considering the weight to be one-third of a grain at 60°. Now, for 100 cubic inches of hydrogen, which in the dry state weigh only 2·118, one-third of a grain is nearly one-seventh of the whole, equivalent to 14 cubic inches of dry gas. But for oxygen, of which 100 cubic inches weigh nearly 34 grains, one-third of a grain forms only 1-110th of the whole.

The quantity of moisture present in air or gas, at any temperature, may indeed be directly determined from my table of the elasticity of aqueous vapour. If we multiply 14.68, which is the weight in grains of 100 cubic inches of steam, by the number 0.516 opposite 60° in my table, we shall have a product, which, divided by 30, will give a quotient = the weight of aqueous vapour in 100 inches of any gas standing over water at the given temperature.

Thus $\frac{14{\cdot}68 \times 0{\cdot}516}{30} = 0{\cdot}2525$. See *infra.*

We have seen, in treating of caloric, that all gaseous matter changes its volume by one 480th part, for the variation of 1° of Fahrenheit's thermometer, departing from the temperature of 32°. This quantity is in decimals = 0·0020833.

The bulk of a gas being inversely as the pressure, it will necessarily *increase* as the barometer *falls*, and *decrease* as it rises. Hence, to reduce the volume of a gas at any pressure, to what it would be under the mean pressure of 30 inches of mercury; multiply the volume by the particular barometrical pressure, and divide the product by 30; the quotient is the true volume. If the gas be contained in a vessel over mercury, so that the liquid metal stands in the inside of the tube higher than on the outside, it is evident that the gas will be compressed by a less weight than the ambient atmosphere, in proportion to the difference of the mercurial levels. If that difference were 10 inches, then one-third of the incumbent pressure would be counterbalanced, and the gas would become bulkier by one-third. Hence, we must subtract this difference of mercurial levels from the barometric altitude at the instant, and use this reduced number or remainder, as the proper multiplier in the above rule. Instead of reducing the volume of a gas to what it would be under a mean pressure of 30 inches, it is often desirable to reduce it to another barometrical height, which existed perhaps at the commencement of the experimental investigthe mercury of the barometer may have moved an inch or more. The general principle, that the volume is inversely as the pressure, measured by the length of the mercurial column, affords the following simple rule:—Multiply the bulk of the gas by the existing height of the barometer, and divide the product by the original height, the quotient is its bulk as at the commencement of the experiment. The barometric pressure is estimated by the inches on its scale, *minus* the difference of mercurial levels in the pneumatic apparatus. By bringing the two surfaces to one horizontal plane, this correction vanishes. The facility of doing so with my eudiometer is one of its chief advantages.

If we are operating in the water pneumatic cistern, we can in general bring the two surfaces to a level. If not, we must allow one inch of mercurial pressure for 13·6 inches of water; and, of course, 1-10th of a barometrical inch for every inch and third of water.

From the researches of Mr. Daniell and Mr. Faraday, it appears that gases are more readily preserved from admixture with atmospheric air, when kept in glass vessels inverted over water, than over mercury. The filtration, in such cases, takes place along the surface of the glass, and not through the pores of the mercury. In this way, air insinuates itself into barometers, occasioning a slow and progressive deterioration of these instruments. The only method of preventing this passage of air, is to bring the mercury into intimate contact with the mouth of the tube, by attaching to its rim at the blowpipe a slender ring of platinum. When the glass, thus armed, is immersed in mercury, the effect is soon perceived; for, instead of any depression being visible around it, the mercury may be lifted by it, considerably above its proper level on the outside, where Mr. Daniell had welded his riband of platinum, about one-third of an inch broad. Intimate contact, in fact, is thus secured between the mercury and the mouth of the tube, so that no air can pass between them.

M. Gay Lussac contrived a very ingenious apparatus, to determine the change of volume which an absolutely dry gas undergoes, when water is admitted to it, in minutely successive portions, till it (or the space it occupies) becomes saturated. He deduced from these accurate experiments the following formula, whose results coincide perfectly with those deducible from Mr. Dalton's and my experiments on the elastic force of aqueous vapour.

When a perfectly dry gas is admitted to moisture, its volume, v, augments, and becomes $\frac{v\,p}{p-f}$; in which p = the barometric water at 60°. Therefore, 100 cubic inches of such aeriform matter, standing in a jar on the hydro-pneumatic trough, must consist of,

98·28 cubic inches dry air = 29·9900 gr.
1·72 aqueous vapour = 0·2525 gr.

Weight of 100 cubic inches of air, over water at 60° = 30·2425

For hydrogen we shall have,

98·28 inches dry gas = 2·08157 gr.
1·72 aqueous vapour = 0·2525

Weight of 100 cubic inches moist gas . . . = 2·33407

Hence its sp. gr. compared to that of dry air, will be $= \frac{2\cdot33407}{30\cdot519} = 0\cdot7648$, and compared to moist air $= \frac{2\cdot33407}{30\cdot2425} = 0\cdot0772$.

For chlorine we shall have (making the sp. gr. of the dry gas = 2·5),

98·28 cubic inches . . = 74·9857
1·72 aqueous vapour . = 0.2525

Weight of 100 cu. in. of moist chl. = 75·2382

Hence, its sp. gr. compared to that of dry air, will be $= \frac{75\cdot2382}{30\cdot519} = 2\cdot2465$, and compared to moist air $= \frac{75\cdot2382}{30\cdot2425} = 2\cdot4878$.

Now, the first is almost the density assigned long ago by MM. Gay Lussac and Thenard; on which, if we make the correction for aqueous vapour present in it, on account of this gas never being collected over mercury, we shall have its true specific grav. = 2·5. Sir H. Davy brought out a number still nearer 2·5 than that of M. Gay Lussac. His chlorine was probably compared with air somewhat moist, and may therefore be considered as readily reducible, by a minute correction, to 2·5. The reason assigned by Dr. Thomson (Annals for Sept. and Oct. 1820) for the former erroneous estimates of the sp. gravity of that gas, cannot surely apply to the two first chemists of the age; namely, that the chlorine they prepared as the standard of comparison was impure. I think the true reason is that which I have now given.

For olefiant and carbonic oxide gases, we shall have,

98·28 cubic inches . . = 29·1564
1·72 vapour . . . = 0·2525

Weight of 100 cub. in. of moist gas = 29·4089

Hence, its sp. gr. compared to that of dry air, will be $= \frac{29\cdot4089}{30\cdot519} = 0\cdot9636$, and to moist air $= \frac{29\cdot4089}{30\cdot2425} = 0\cdot9724$.

GASES (Liquefaction of). See Acid (Carbonic). Acid (Sulphurous), Chlorine, Cyanogen, &c.

GASTRIC JUICE, is separated by glands placed between the membranes which line the stomach; and from these it is emitted into the stomach itself.

From various experiments it follows:

1. That the gastric juice reduces the aliments into an uniform *magma*, even out of the body, and *in vitro;* and that it acts in the same manner on the stomach after death; which proves that its effect is chemical, and almost independent of vitality. 2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration. 3. That though there is no trituration in membranous stomachs, this action powerfully assists the effect of the digestive juices in animals with a muscular stomach, such as ducks, geese, pigeons, &c. Some of these animals, bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass, which were introduced into their stomachs. Spallanzani has ascertained, that flesh, included in spheres sufficiently strong to resist the muscular action, was completely digested. 4. That gastric juice acts by its solvent power, and not as a ferment; because the ordinary and natural digestion is attended with no disengagement of air, or inflation, or heat, or, in a word, with any other of the phenomena of fermentation.

GAY-LUSSITE. A new mineral, found by M. Boussingault in great abundance, at Lagunilla, a small Indian village, to the south-west of Merida. It is in transparent and colourless crystals (very imperfect in form), or sometimes greyish and semi-transparent, with a dull surface. They cause double refraction. Sp. gr. 1·93 to 1·95. By heat, they decrepitate, become opaque, and yield much water. Before the blowpipe a fragment fuses into a globule, which instantly becomes infusible, and is then alkaline to the taste. It dissolves in small quantity in water, yielding a solution which reddens turmeric paper, and is precipitated by oxalic acid. It consists, in 100 parts, of carbonic acid, 28·66; soda, 20·44; lime, 17·7; alumina, 1; water, 32·2; or of an atom of carbonate of soda, an atom carbonate of lime, and 11 atoms of water. *Ann. de Chim.* xxxi. 270.

GEHLENITE. A mineral substance, allied to Vesuvian. Its colours are olive-green, leek-green, green of other shades, and brown. It occurs crystallized in rectangular four-sided prisms, which are so short as to appear tables. Lustre glistening, often dull. Cleavage imperfect, but three-fold rectangular. Fracture fine splintery. Translucent on the edges. Rather easily frangible. Harder than felspar, but softer than quartz. Sp. gr. 2·98. It melts before the blowpipe into a brownish-yellow transparent glass. It is found along with calcareous spar in the valley of Fassa in the Tyrol. Its constituents are, lime 35·5, silica 29·64, alumina 24·8, oxide of iron 6·56, volatile matter 3·3.

GELATIN, GELLY, or **JELLY,** an animal substance, soluble in water, capable of assuming a well-known elastic or tremulous consistence, by cooling, when the water is not too abundant, and liquefiable again by increasing its temperature. This last property distinguishes it from albumen, which becomes consistent by heat. It is precipitated in an insoluble form by tannin; and it is this action of tannin on gelatin that is the foundation of the art of tanning leather. See Glue.

According to the analysis of MM. Gay Lussac and Thenard, gelatin is composed of

Carbon	47·881
Oxygen	27·207
Hydrogen	7·914
Azote	16·998
	100·000

GEMS. This word is used to denote such stones as are considered by mankind as precious. These are, the diamond, the ruby, the sapphire, the topaz, the chrysolite, the beryl, the emerald, the hyacinth, the amethyst, the garnet, the tourmalin, the opal; and to these may be added, rock crystal, the finer flints or pebbles, the cat's eye, the oculus mundi, or hydrophanes, the chalcedony, the moon-stone, the onyx, the cornelian, the sardonyx, agates, and the Labrador-stone; for which, consult the several articles respectively.

GEODES. A kind of ætites, the hollow of which, instead of a nodule, contains only loose earth, and is commonly lined with crystals.

GEOGNOSY. See Geology.

GEOLOGY. A description of the structure of the earth. This study may be divided, like most others, into two parts; observation and theory. By the first we learn the relative positions of the great rocky or mineral aggregates that compose the crust of our globe; through the second, we endeavour to penetrate into the causes of these collocations. A valuable work was some time since published, comprehending a view of both parts of the subject, by Mr. Greenough, to which I refer my readers for much instruction, communicated in a very lively manner.

Very recently the world has been favoured with the first part of an excellent view of this science by Messrs. Conybeare and Phillips, in their "Outlines of the Geology of England and Wales;" from which work, the following brief sketch of the subject is taken: The

Traité de Geognosie of D'Aubuisson bears a high character on the continent. He is a liberal Wernerian.

WERNER's *Table of the different Mountain Rocks, from Jameson.*

CLASS I.

Primitive rocks.

1. Granite.
2. Gneiss.
3. Mica-slate.
4. Clay-slate.
5. Primitive limestone.
6. Primitive trap.
7. Serpentine.
8. Porphyry.
9. Syenite.
10. Topaz rock.
11. Quartz rock.
12. Primitive flinty-slate.
13. Primitive gypsum.
14. White stone.

CLASS II.

Transition rocks.

1. Transition limestone.
2. Transition trap.
3. Greywacke.
4. Transition flinty-slate.
5. Transition gypsum.

CLASS III.

Floetz rocks.

1. Old red sandstone, or first sandstone formation.
2. First or oldest floetz limestone.
3. First or oldest floetz gypsum.
4. Second or variegated sandstone formation.
5. Second floetz gypsum.
6. Second floetz limestone.
7. Third floetz limestone.
8. Rock-salt formation.
9. Chalk formation.
10. Floetz-trap formation.
11. Independent coal formation.
12. Newest floetz trap formation.

CLASS IV.

Alluvial rocks.

1. Peat.
2. Sand and gravel.
3. Loam.
4. Bog-iron ore.
5. Nagelfluh.
6. Calc-tuff.
7. Calc sinter.

CLASS V.

Volcanic rocks.

* Pseudo-volcanic rocks.

1. Burnt clay.
2. Porcelain jasper.
3. Earth slag.
4. Columnar clay ironstone.
5. Polier, or polishing slate.

* * *True volcanic rocks.*

1. Ejected stones and ashes.
2. Different kinds of lava.
3. The matter of muddy eruptions.

The primitive rocks lie undermost, and never contain any traces of organized beings imbedded in them. The transition rocks contain comparatively few organic remains, and approach more nearly to the chemical structure of the primitive than the mechanical of the secondary rocks. As these transition rocks were taken by Werner from among those which in his general arrangement were called secondary, the formation of that class made it necessary to abandon the latter term. To denote the mineral masses reposing on his transition series, he accordingly employed the term floetz rocks, from the idea that they were generally stratified in planes nearly horizontal, while those of the older strata were inclined to the horizon at considerable angles. But this holds good with regard to the structure of those countries only which are comparatively low: in the Jura chain, and on the borders of the Alps and Pyrenees, Werner's floetz formations are highly inclined. Should we therefore persist in the use of this term, says Mr. Conybeare, we must prepare ourselves to speak of vertical beds of floetz, (*i. e.* horizontal), limestone, &c. As the inquiries of geologists extended the knowledge of the various formations, Werner, or his disciples, found it necessary to subdivide the bulky class of floetz rocks into floetz and newest floetz, thus completing a fourfold enumeration. Some writers have bestowed the term *tertiary* on the newest floetz rocks of Werner. The following synoptical view of geological arrangement is given by the Rev. Mr. Conybeare.

CHARACTER.	PROPOSED NAMES.	WERNERIAN NAMES.	OTHER WRITERS.
1. Formations (chiefly of *sand* and *clay*) above the chalk.	*Superior order.*	Newest floetz class.	Tertiary class.
2. Comprising, a. Chalk. b. Sands and clays, *beneath the chalk.* c. Calcareous freestones (*oolites*) and argillaceous beds. d. *New red sandstone, conglomerate, and magnesian limestone.*	*Supermedial order.*	Floetz class.	Secondary class.
3. Carboniferous rocks, comprising, a. *Coal measures.* b. *Carboniferous limestone.* c. *Old red sandstone.*	*Medial order.*	Sometimes referred to the preceding, sometimes to the succeeding class, by writers of these schools; very often the coal measures are referred to the former, the subjacent limestone and sandstone to the latter.	
4. *Roofing slate*, &c. &c.	*Submedial order.*	Transition class.	Intermediate class.
5. *Mica slate, gneiss, granite*, &c.	*Inferior order.*	Primitive class.	Primitive class.

In all these formations, from the lowest to the highest, we find a repetition of rocks and beds of similar chemical composition; *i. e.* siliceous, argillaceous, and calcareous, but with a considerable difference in texture; those in the lowest formations being compact and often crystalline, while those in the highest and most recent are loose and earthy. These repetitions form what the Wernerians call formation suites. We may mention,

1*st*, The *limestone suite.* This exhibits, in the inferior or primitive order, crystalline marbles; in the two next, or transition and carboniferous orders, compact and subcrystalline limestones (Derbyshire limestone); in the supermedial or floetz order, less compact limestone (lias), calcareous freestone (Portland and Bath stone), and chalk; in the superior or newest floetz order, loose earthy limestones.

2*d*, The *argillaceous suite* presents the following gradations; clay-slate, shale of the coal-measures, shale of the lias, clays alternating in the oolite series, and that of the sand beneath the chalk; and, lastly, clays above the chalk.

3*d*, The *siliceous suite* may (since many of the sandstones of which it consists present evident traces of felspar and abundance of mica, as well as grains of quartz, and since mica is more or less present in every bed of sand), perhaps deserve to have granite placed at its head, as its several members may possibly have been derived from the detritus of that rock: it may be continued thus; quartz rock and transition sandstone, old red sandstone, millstone-grit, and coal-grits, new red sandstone, sand and sandstone beneath the chalk, and above the chalk. In all these instances a regular diminution in the degree of consolidation may be perceived in ascending the series.

We noticed before, that the remains of vegetables and animals are confined to the secondary formations. We have now to add, that they are not irregularly dispersed throughout the whole series of these formations, but disposed as it were in families, each formation containing an association of species peculiar in many instances to itself, widely differing from those of other formations, and accompanying it throughout its whole course; so that at two distinct points on the line of the same formation, we are sure of meeting the same general assemblage of fossil remains. It will serve to exemplify the laws which have been stated, if the observer's attention is directed to two of the most prominent formations of this island; namely, the chalk and the limestone which underlie the coal in Northumberland, Derbyshire, South Wales, and Somerset. Now if he examines a collection of fossils from the chalk of Flamborough-Head, or from that of Dover-Cliffs, or, it may be added, from Poland or Paris, he will find eight or nine species out of ten the same; he will observe the same echinites associated with the same shells; nearly one-half of these echinites he will perceive to belong to divisions of that family unknown in a recent state, and indeed in any other fossil bed except the chalk. If he next proceeds to inspect parcels of fossils from the carboniferous limestone, he will in the same manner find them to agree with each other, from whichever of the above localities they may have been brought; that is, he will find the same corals, the same encrinites, the same productæ, terebratulæ, spiriferæ, &c. But, lastly, if he compares the collection from the chalk with that from the mountain lime, he will not find one single instance of specific agreement, and in very few instances any thing that could deceive even an unpractised eye, by the superficial resemblance of such an agreement.

If we cast a rapid view over the phenomena of this distribution, the subject must appear to present some of the most singular problems which can engage the attention of the inquirer into nature. First we have a foundation of primitive rocks destitute of these organic remains; in the next succeeding series (that of transition), corals, encrinites, and testacea, different however from those now known, appear at first sparingly. The fossil remains of the carboniferous limestone are nearly of the same nature with those in the transition rocks, but more abundant; the coal-measures (coal strata), however, themselves, which repose on this limestone, present scarcely a single shell or coral; but, on the contrary, abound with vegetable remains, ferns, flags, reeds of unknown species, and large trunks of succulent plants, *strangers to the present globe*. Upon the coal rest beds again containing marine remains (the magnesian limestone), then a long interval (of new red sandstone) intervenes, destitute almost, if not entirely, of organic remains, preparing the way, as it were, for a new order of things. This order commences in the lias, and is continued in the oolites, green and iron sands, and chalk. All these beds contain corals, encrinites, echinites, testacea, crustacea, vertebral fishes, and marine oviparous quadrupeds, yet widely distinguished from the families contained in the lower beds of the transition and carboniferous class, and particularly distinguished among themselves, according to the bed which they occupy. Hitherto the remains are always petrified, *i. e.* impregnated with the mineral substance in which they are imbedded. But, lastly, in the strata which cover the chalk, we find the shells merely preserved, and in such a state, that when the clay or sand in which they lie is washed off, they might appear to be recent, had they not lost their colour, and become more brittle. Here we find beds of marine shells alternating with others peculiar to fresh water, so that they seem to have been deposited by *reciprocating inundations of fresh and salt water*. In the highest of the regular strata, the crag, we at length can find an identity with the shells at present existing on the same coast; and, lastly, over all these strata indiscriminately there is spread a covering of gravel (seemingly formed by the action of a deluge, which has detached and rounded by attrition fragments of the rocks over which it swept), containing the remains of numerous land quadrupeds, many of them of unknown genera or species, (the mastodon, and the fossil species of elephant, or mammoth, bear, rhinoceros, and elk), mingled with others (hyænas, &c.) equally strangers to the climates where they are now found, yet associated with many at present occupying the same countries.

Another class of substances imbedded in the secondary strata, and throwing light on the convulsions amidst which they have been formed, are the pebbles, or rolled fragments of rocks, older than themselves, which they are often found to contain. Thus the lower beds of the supermedial order (namely, the conglomerate rocks of the new red sandstone) contain in great abundance rolled fragments of the carboniferous limestone belonging to the class next below it (the medial order), as well as of many still older rocks; being in fact only a consolidated mass of gravel, composed of *debris* of these rocks.

The necessary inferences from this fact are, first, The rock whence the fragments were derived must have been consolidated, and, subsequently to that consolidation, have been exposed to the mechanical violence (probably the action of agitated waters) which tore from it these masses, and rounded them by attrition, before the rock in which these fragments are now imbedded was formed; and, secondly, Since loose gravel beds (and such must have been the original form of these, though now consolidated into conglomerate rocks) cannot be accumulated to any extent from the action of gravity on a highly inclined plane, we are sure, when we find such beds, as we often do in nearly vertical strata, that this cannot have been their original position, but is one into which they have been forced by convulsions which have dislocated them subsequently to their consolidation. These consolidated gravel beds are called conglomerates, breccias, or pudding stones; we find them among the transition rock, in the old red sandstone, in the millstone-grits and coal-grits, in the lower members of the new red sandstone, in the sand strata beneath the chalk, and in the gravel beds associated with the plastic clay, and interposed between the chalk and great London clay.

From the occurrence of the marine remains lately noticed, occupying, as they do, rocks spread over two-thirds of the surface of every part of our continents which have been explored, and rising to the highest situations, even to the loftiest summits of the Pyrenees, and still more elevated points on the Andes, it is an inevitable inference, that the greater part of these continents have not only been covered by, but have been formed of materials collected within the bosom of the ocean; that we inhabit countries which we may truly call *factas ex æquore terras.* The great and fundamental problem, therefore, of theoretical geology, is obviously to assign adequate causes for the change of level in this ocean, which has permitted these masses, which once formed the bottom of its channel, to rise in hills and mountains above its waves. The causes which it is possible to imagine are reducible to two general classes. First, The decrease of the absolute quantity of water. This must have resulted from causes entirely chemical, namely, the decomposition of some portion of the water, its constituents entering into new forms of combination; and its fixation in the rocks formed beneath it. It is probable that these causes have operated to some degree, but it seems impossible to ascribe to them the very great difference of level for which we have to account.

The second class of possible causes is entirely mechanical; those, namely, which may have produced a change of relative level without any diminution of absolute quantity in the waters.

The causes of this kind which have been proposed are, first, The absorption of the waters into a supposed central cavity; but the now ascertained density of the earth (being greater than that which would result from an entirely solid sphere of equal magnitude of the most compact known rock) renders the existence of any such cavity very doubtful.

Secondly, A writer in the Journal of the Royal Institution, vol. ii. has proposed the very ingenious hypothesis, that a change of temperature of a few degrees will, from the unequal expansibility of the materials of land and water, sufficiently account for this change of level.

Thirdly, It has been ascribed to violent convulsions, which have either heaved up the present continents, or, which amounts to the same thing (as the same relative change must have taken place in either view), depressed the present channel of the ocean. If the violent elevation of the continent, or depression of the channel of the ocean, supposed in the last mentioned hypothesis, really took place, it must have left traces in the disturbed, contorted, and highly inclined position of the strata; and these disturbances must be the greatest where the change of level has been the greatest, *i. e.* in the neighbourhood of the loftiest mountains. Now this is actually the case.

In support of the hypothesis which ascribes an important part to volcanic agency in modifying the surface of our planet, the following, at least plausible, arguments might be adduced.

1. It must be kept in view, that the object is to assign an adequate cause for the undoubted fact of the emergence of the loftiest mountains of the present continent; and that when so mighty an effect is to be accounted for, the mind must be prepared to admit, without being startled, causes of a force and energy greatly exceeding those with which we are acquainted from actual observation.

2. The broken and disturbed state, and inclined position of the strata composing those continents, many of which must have been at the time of their original formation horizontal, indicate, as we have seen, that one at least of the causes operating to effect this great change of relative level between the land and waters, was the elevation of the former by mechanical force.

3. The only agent with which we are acquainted, whose operation bears any analogy to the effects above specified, is the volcanic energy, which still occasionally forms new islands, and elevates new mountains.

4. Although these effects are now indeed partial and limited, yet there is certain proof that volcanic agency has formerly been much more active; the extinct volcanoes of the Rhine, Hungary, and Auvergne, as well as those which occupy so large a portion of Italy, where only one remains in activity, concur in proving, that at present we experience only the expiring efforts, as it were, of those gigantic powers which have once ravaged the face of nature.

5. If to this certain proof of the greater prevalence of volcanic convulsions in earlier, but still comparatively recent, periods of the history of our planet, we add the presumption that the trap rocks (so singularly intruded among the regular strata, and producing, where they traverse those strata, so precisely the effects of heat acting under compression, and so different in all their phenomena from formations decidedly aqueous), were of volcanic origin, we shall find that scarcely a country exists, which has not been a prey to the ravages of this powerful principle. If, with many of the best geological observers, (Dr. M'Culloch, Von Buch, Necker, &c.) we incline to extend the same conclusions to granitic rocks, a mass of volcanic power, clearly adequate to all the required effects, is provided.

6. The question will undoubtedly present itself, what is the source of volcanic action? and sufficient proof exists, that this source is deeply seated beneath the lowest rocks with which our examination of the earth's surface makes us acquainted; for, in Auvergne, the lavas have evidently been erupted from beneath the primitive rocks.

7. The very important recent discoveries with regard to the increased temperature noticed in descending deep mines, &c. by Messrs.

Fox and Fourrier, will, if confirmed by further examination, prove, that some great source of heat exists beneath the earth's crust.

8. A degree of presumption may be thought to arise from these considerations, that the crust of the earth rests on a heated nucleus, the true source of volcanic energy. If this nucleus be in a fluid or viscous state, its undulations would readily account for the convulsions which have affected that crust, both in originally dislocating and elevating portions of its strata, and in the actual phenomena of earthquakes (of many of which phenomena no other hypothesis appears to offer a sufficient explanation), while, at the same time, it would afford an adequate reason for the figure of the globe as a spheroid of rotation.

9. On this supposition, we should at once perceive a reason why the effects of the volcanic force may have been much more violent in earlier periods, while that mass of deposites which now covers the supposed volcanic nucleus was but gradually forming over it than at present; and we shall also find a reason for the higher temperature, which many of the remains of both the animal and vegetable kingdoms, found in the strata of countries now too cold for the existence of their recent analogies, appear to indicate as having formerly prevailed.

10. It must be remembered, that one of the essential conditions of the theory above sketched is, the operation of volcanic agency beneath the pressure of an incumbent ocean; and that it does not, therefore, in any degree question the Neptunian origin of the majority of the rocks which have evidently been formed in the bosom of the ocean. With regard to the trap rocks alone, and perhaps the granitic, does it venture even to insinuate an opposite mode of formation.

Mr. Conybeare next shows, that the Wernerian generalization of the phenomena is too hasty. It supposes the basset edges of the strata to occupy levels successively lower and lower in proportion as they are of less ancient formation, and as they recede from the primitive chains, forming the edges of the basins in which they have been deposited. For if we compare the basset edges of the same strata on the opposite sides of the great European basin (assuming the primitive ranges of our own island as one of its borders, and those of the Alpine chains as the other), we shall find their level totally different.

The oolite, for instance, whose highest point with us is less than 1200 feet, attains a height of more than 4000 in the Jura chain, and in the mountains of the Tyrol has been observed by Mr. Buckland crowning some of the loftiest and most rugged summits of the Alps themselves. Again, if we compare the inclination of the strata at the edges of the basin, we shall find every thing but the supposed regular gradation, from a highly elevated to a horizontal position; on the contrary, we shall see the horizontal beds generally reposing at once upon the truncated edges of those which lie at very considerable angles; and in place of the general conformity or parallelism which ought to prevail between the several formations, we shall observe, in many instances, appearances of the greatest irregularity in this respect; and these irregularities will be found to increase in approaching those chains which are the most elevated.

But if we suppose, that during the regular and gradual subsidence of the level of the ocean, in the Wernerian system, the continents were elevated by mechanical forces acting in a series of great convulsions, we shall perhaps obtain a nearer approximation to agreement with the actual phenomena, as deduced from observation. If these convulsions resulted from volcanic agency, we have already seen that there is every reason to believe this cause to have acted with most violence in the earliest periods; and this will sufficiently account for the greater derangement of the earlier rocks.

That the valleys have been, in many instances, entirely excavated by the agency of powerful aqueous currents, and in all, greatly modified by the same cause, seems as completely proved as the nature of the case can possibly admit. The same diluvial agency that has excavated the valleys, appears also to have swept off the superior strata from extensive tracts which they once covered. The proofs of this are to be found in insulated hills, or *outliers* of those strata, placed at considerable distances from their continuous range, with which they have every appearance of having been once connected; in the abrupt and truncated escarpments which form the usual termination of the strata, and in the very great quantity of their *debris*, scattered frequently over tracts far distant from those where they still exist *in situ*. This stripping off the *superstrata* is appropriately termed *denudation*.

The most important agency of this kind appears to have been exerted at an early period, and subsequently to the consolidation of all the strata, by an inundation which must have swept over them universally, and covered the whole surface with their *debris* indiscriminately thrown together, forming the last great geological change to which the surface of our planet appears to have been exposed.

To this general covering of water-worn *debris* derived from all the strata, the name of *diluvium* has been given, from the consideration of that great and universal catastrophe to which it seems most properly assignable. By this name it is intended to distinguish it from the partial *debris* occasioned by causes still in operation; such as the slight wear produced by the present rivers, the more violent action of torrents, &c. To the latter the name of *alluvium* has lately been appropriated. It does not seem possible to assign any single and uniform direction to the currents which have driven the diluvial *debris* before them; but they appear in every instance to have flowed (which indeed must of necessity be the case with the currents of subsiding waters) as they were determined by the configuration of the adjoining country; from the mountains, that is, towards the lower hills and plains. As far as England is concerned, this principle will produce a general tendency to a direction from north-west towards south and east, greatly modified, however, by obvious local circumstances.

Another circumstance connected with the distribution of these travelled fragments is, that we often find them in masses of considerable size, accumulated in situations now separated by the intervention of deep valleys from the parent hills (if we may so speak), whence we know them to have been torn. This appears to be a demonstrative proof that these intervening valleys must have been excavated subsequently to the transportation of these blocks; for though we can readily conceive how the agency of violent currents may have driven these blocks down an inclined plane, or if the *vis a tergo* were sufficient, along a level surface, or even up a very slight and gradual acclivity, it is impossible to ascribe to them the Sisyphean labour of rolling rocky masses, sometimes of many tons in weight, up the face of abrupt and high escarpments. The attention of geologists was first directed to this phenomenon by the discoveries of Saussure, who noticed one of its most striking cases—the occurrence of massive fragments torn from the primitive chains of the Alps, scattered at high levels on the escarpment of the opposite calcareous and secondary chains of the Jura, although between the two points the deep valley containing the lake of Geneva is interposed. This phenomenon is one of very common occurrence. The Downs surrounding Bath (Hampton Down for example), though abruptly scarped, and surrounded by valleys more than 600 feet deep, have yet on their very summits flints transported from the distant chalk hills. The simplest explanation of the fact will be, that these fragments were transported by the first action of the currents, before they had effected the excavation of the valleys, now cutting off all communication with the native rocks whence they were derived.

The organic remains of land animals dispersed through this diluvial gravel must, with the greatest probability, be referred to the races extinguished by the great convulsion which formed that gravel; many of them are of species still inhabiting the countries where they are thus found; some of the species now inhabiting only other climates; and some few, of species and genera now entirely unknown.

To the same period we may ascribe the bones *of the same species with the above*, found in many caverns; but, in many of these instances, it is probable that some of the animals now found there, previously inhabited them as their dens. Professor Buckland appears to have proved satisfactorily, that this must have been the case in the remarkable instance of the cavern lately discovered near Kirby Moorside, Yorkshire. Here the remains found in the greatest abundance are those of hyænas; with these are mingled fragments of various animals, from the mammoth to the water-rat. All the bones present evident traces of having been mangled and gnawed; and the whole are buried in a sediment of mud subsequently incrusted over by stalactitical depositions. Professor Buckland's explanation is, that this cavern was occupied by the hyænas; who, according to the known habits of these animals, partially devoured even the bones of their prey, and dragged them for that purpose to their dens; around their retreats, a similar *congeries* of mangled bones has been noticed by recent travellers. The proofs of these points, deduced from the circumstances of the cavern, the state of the bones, and the ascertained habits of the animals in question, appear to be decisive. The sediment in which the bones are imbedded, and the occurrence of the remains of the mammoths, and other species, only known (in these climates at least) in a fossil state, in the diluvial gravel, clearly refer their remains to the same era. Caverns containing bones of a similar class, the mammoth, the fossil species of rhinoceros, &c. have been found near Swansea, at Hatton-hill, (on the Mendip chain in Somersetshire), and near Plymouth.—*Rev. W. D. Conybeare, Introduction.*

The ancient history of the globe, which may be regarded as the *ultimate* object of geological researches, is undoubtedly one of the most curious subjects that can engage the attention of enlightened men. The lowest and most level parts of the earth, when penetrated to a very great depth, exhibit nothing but horizontal strata, composed of various substances, and containing almost all of them innumerable marine productions. Similar strata, with the same kind of productions, compose the hills even to a great height. Sometimes the shells are so numerous as to constitute the entire body of the stratum. They are almost everywhere in such a perfect state of preservation, that even the smallest of them retain their most delicate parts, their sharpest ridges, and tenderest processes. They are found in elevations far above the level of every part of the ocean, and in places to which the sea could not be conveyed by any presently existing cause. They are not merely enclosed in loose sand, but are often incrusted and penetrated on all sides by the hardest stones. Every part of the earth, every hemisphere, every continent, every island of any size, exhibits the same phenomenon. We are therefore forcibly led to believe, not only that the sea has at one period or another covered all our plains, but that it must have remained there for a long time, and in a state of tranquillity; which circumstance was necessary for the formation of deposites so extensive, so thick, in part so solid, and containing *exuviæ* so perfectly preserved. A nice and scrupulous comparison of the forms, contexture, and composition of these shells, and of those which still inhabit the sea, cannot detect the slightest difference between them. They have therefore once lived in the sea, and been deposited by it; the sea consequently must have rested in the places where the deposition has taken place. Hence it is evident, that the basin or reservoir containing the sea has undergone some change, either in extent, situation, or both.

The traces of revolutions become still more apparent and decisive when we ascend a little higher, and approach nearer to the foot of the great chain of mountains. There are still found many beds of shells; some of these are even larger and more solid; the shells are quite as numerous, and as entirely preserved; but they are not of the same species with those which were found in the less elevated regions. The strata which contain them are not so generally horizontal; they have various degrees of inclination, and are sometimes situated vertically. While in the plains and low hills it was necessary to dig deep in order to detect the succession of the strata, here we perceive them by means of the valleys, which time or violence has produced, and which disclose their edges to the eye of the observer.

Thus the sea, previous to the formation of the horizontal strata, had formed others, which by some means have been broken, lifted up, and overturned in a thousand ways. But the sea has not always deposited stony substances of the same kind. It has observed a regular succession as to the nature of its deposites; the more ancient the strata are, so much the more uniform and extensive are they; and the more recent they are, the more limited are they, and the more variation is observed in them at small distances. Thus the great catastrophes which have produced revolutions in the basins of the sea, were preceded, accompanied, and followed by changes in the nature of the fluid, and of the substances which it held in solution; and when the surface of the seas came to be divided by islands and projecting ridges, different changes took place in every separate basin.

These irruptions and retreats of the sea have neither been slow nor gradual; most of the catastrophes which have occasioned them have been sudden; and this is easily proved, especially with regard to the last of them, or the Mosaic deluge, the traces of which are very conspicuous. In the northern regions it has left the carcasses of some large quadrupeds, which the ice had arrested, and which are preserved even to the present day, with their skin, their hair, and their flesh. If they had not been frozen as soon as killed, they must have been quickly decomposed by putrefaction. But this perpetual frost could not have taken possession of the regions which these animals inhabited, except by the same cause which destroyed them: this cause must therefore have been as sudden as its effect. The two most remarkable phenomena of this kind, and which must for ever banish all idea of a slow and gradual revolution, are the rhinoceros, discovered in 1771 on the banks of the *Vilhoui*, and the elephant, recently found by Mr. Adams near the mouth of the *Sena*. This last retained its flesh and skin, on which was hair of two kinds; one short, fine, and crisped, resembling wool, and the other like bristles. The flesh was still in such high preservation, that it was eaten by dogs. Every part of the globe bears the impress of these great and terrible events so distinctly, that they must be visible to all who are qualified to read their history in the remains which they have left behind.—*See Cuvier's Theory of the Earth.*

I shall conclude this article by stating, that this naturalist, the most learned of the present day, as well as Dolomieu, Deluc, and Greenough, concur in thinking, that not above 5000 or 6000 years have elapsed since the period of the deluge, which agrees with the Mosaic epoch of that catastrophe.

GERMINATION. The vital development of a seed, when it first begins to grow.

GIBBSITE. This mineral commonly occurs in irregular stalactites from one to three inches in length, and not less than an inch in diameter. Sometimes in large tuberous masses. Structure indistinctly fibrous. Somewhat harder than calcareous spar. Slightly translucent. Of a dirty white colour. Sp. grav. 2.40. It contains alumina 64.8, water 34.7. Infusible before the blowpipe. It is found at Richmond in Massachusets, N. America, in a neglected mine of brown hæmatite ore. *Phillips' Mineralogy.*

GIESECKITE. The name given by Stromeyer to a mineral discovered by M. Giesecke, of a grey and brown colour, white streak, and specific gravity 2.7 to 2.9. It belongs to the rhomboidal system of Mohs. Its form is designated $R - \infty, R + \infty$. No cleavage.

GILDING. The art of covering the surfaces of bodies with gold.

The gold prepared for painting is called shell-gold or gold-powder, and may be obtained by amalgamating one part of gold with eight of quicksilver, and afterward evaporating the latter, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration. For this purpose, gold leaf must be ground with honey or strong gum-water for a long time;

and when the powder is sufficiently fine, the honey or gum may be washed off with water.

For gold gilding by friction, a fine linen rag is steeped in a saturated solution of gold till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterward burned to tinder. Now, when any thing is to be gilded, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterward into the black powder; and the piece, after it is burnished, rubbed with it.

For water gilding, the solution of gold may be evaporated till it is of an oily consistence, suffered to crystallize, and the crystals dissolved in water be employed instead of the acid solution. If this be copiously diluted with alcohol, a piece of clean iron will be gilded by being steeped therein. Or add to the solution about three times its quantity of sulphuric ether, which will soon take up the nitro-muriate of gold, leaving the acid colourless at the bottom of the vessel, which must then be drawn off. Steel dipped into the ethereal solution for a moment, and instantly washed in clean water, will be completely and beautifully covered with gold. The surface of the steel must be well polished, and wiped very clean.

For the method called Grecian gilding, equal parts of sal ammoniac and corrosive sublimate are dissolved in nitric acid, and a solution of gold is made in this menstruum: upon this the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but, on being exposed to a red heat, it assumes the appearance of gilding.

The method of gilding silver, brass, or copper, by an amalgam, is as follows: Eight parts of mercury, and one of gold, are incorporated together by heating them in a crucible. As soon as the gold is perfectly dissolved, the mixture is poured into cold water, and is then ready for use.

Before the amalgam can be laid upon the surface of the metal, this last is brushed over with dilute aquafortis, in which it is of advantage that some mercury may have been dissolved. Some artists then wash the metal in fair water, and scour it a little with fine sand, previous to the application of the gold; but others apply it to the metal while still wet with the aquafortis. But in either case the amalgam must be laid on as uniformly as possible, and spread very evenly with a brass-wire brush, wetted from time to time with fair water. The piece is then laid upon a grate over a charcoal fire, or in a small oven or furnace adapted to this purpose. The heat drives off the mercury, and leaves the gold behind. Its defects are then seen, and may be remedied by successive applications of mere amalgam, and additional application of heat. The expert artists, however, make these additional applications while the piece remains in the furnace, though the practice is said to be highly noxious on account of the mercurial fumes. After this it is rubbed with gilders' wax, which may consist of four ounces of bees' wax, one ounce of verdigris, and one ounce of sulphate of copper; then expose it to a red heat, which burns off the wax; and, lastly, the work is cleared with the scratch brush, and burnished, if necessary, with a steel tool. The use of the wax seems to consist merely in covering defects, by the diffusion of a quantity of red oxide of copper, which is left behind after the burning.

The gilding of iron by mere heat is performed by cleaning and polishing its surface, and then heating it till it has acquired a blue colour. When this has been done, the first layer of gold leaf is put on, slightly burnished down, and exposed to a gentle fire. It is usual to give three such layers, or four at the most, each consisting of a single leaf for common works, or two for extraordinary ones. The heating is repeated at each layer, and last of all the work is burnished.

The gilding of buttons is done in the following way: When the buttons, which are of copper, are made, they are dipped into dilute nitric acid to clean them, and then burnished with a hard black stone. They are then put into a nitric solution of mercury, and stirred about with a brush till they are quite white. An amalgam of gold and mercury is then put into an earthen vessel with a small quantity of dilute nitric acid, and in this mixture the buttons are stirred, till the gold attaches to their surface. They are then heated over the fire, till the mercury begins to run, when they are thrown into a large cap made of coarse wool and goat's hair, and in this they are stirred about with a brush. The mercury is then volatilized by heating over the fire in a pan, to the loss of the article, and injury of the workmen's health; though the greater part might be recovered, with less injury to the operators. By Act of Parliament, a gross of buttons, of an inch diameter, are required to have five grains of gold on them; but many are deficient even of this small quantity.

Painting with gold upon porcelain or glass is done with the powder of gold, which remains behind after distilling the aqua regia from a solution of that metal. It is laid on with borax and gum water, burned in, and polished. The gilding of glass is commonly effected by covering the part with a solution of borax, and applying gold leaf upon it, which is afterward fixed by burning.

Gilding in oil is performed by means of a paint sold under the name of gold size. It consists of drying oil, (that is to say, linseed oil boiled upon litharge), and mixed with yellow ochre. It is said to improve in its quality by keeping. This is laid upon the work; and when it has become so dry as to adhere to the fingers without soiling them, the gold leaf is laid on, and pressed down with cotton. This method of gilding is proper for work intended to be exposed to the weather.

The method of gilding in burnished gold consists in covering the work with parchment size and whiting, thinly laid on at five or six different times. This is covered with a yellow size made of Armenian bole, a little wax, and some parchment size; but in this, as in most other compositions used in the arts, there are variations which depend on the skill or the caprice of the artists. When the size is dry, the gold is applied upon the surface previously wetted with clear water. A certain number of hours after this application, but previous to the perfect hardening of the composition, the gold may be very highly burnished with a tool of agate made for this purpose. This gilding is fit only for work within doors; for it readily comes off upon being wetted.

The edges of the leaves of books are gilded by applying a composition of one part Armenian bole, and one quarter of a part of sugar-candy, ground together with white of eggs. This is burnished while the book remains in the press, and the gold is laid on by means of a little water.

Leather is gilded either with leaf-brass or silver, but most commonly by the latter, in which case a gold-coloured varnish is laid over the metal. Tin-foil may be used instead of silver-leaf for this less perfect gilding upon such works as do not possess flexibility.

GISMONDINE. Abrazite.

GLACIES MARIÆ. Mica.

GLANCE. The name annexed to certain minerals which have a metallic or pseudo-metallic lustre. Thus we see glance-coal, lead-glance, antimony-glance, &c.

GLASS. Most of the treatises which I have seen on the manufacture of glass, illustrate a well known position, that it is easy to write a large volume, which shall communicate no definite information. There are five distinct kinds of glass at present manufactured :—

1. Flint glass, or glass of lead.
2. Plate glass, or glass of pure soda.
3. Crown glass, the best window-glass.
4. Broad glass, a coarse window-glass.
5. Bottle, or coarse green glass.

1. *Flint Glass*, so named because the siliceous ingredient was originally employed in the form of ground flints. It is now made of the following composition : —

Purified Lynn sand,	100 parts
Litharge or red lead,	60
Purified pearl ash,	30

To correct the green colour derived from combustible matter, or oxide of iron, a little black oxide of manganese is added, and sometimes nitre and arsenic. The fusion is accomplished usually in about thirty hours.

2. *Plate Glass.* Good carbonate of soda procured by decomposing common salt with pearl ash, is employed as the flux. The proportion of the materials is,

Pure sand,	43·0
Dry subcarbonate of soda,	26·5
Pure quicklime,	4·
Nitre	1·5
Broken plate glass,	25·0
	100·0

About seventy parts of good plate glass may be run off from these materials.

3. *Crown, or fine window-glass.* This is made of sand vitrified by the impure barilla, manufactured by incineration of sea weed on the Scotch and Irish shores. The most approved composition is,

	By measure.	By weight.
Fine sand purified,	5 —	200
Best kelp ground,	11 —	330

These ingredients are mixed, and then thrown into the fritting arch, where the sulphur of the kelp is dissipated, and the matters are thoroughly incorporated, forming, when withdrawn at the end of four hours, a greyish-white tough mass, which is cut into brick-shaped pieces, and after concretion and cooling, piled up for use. By long keeping a soda efflorescence forms on their surface. They are then supposed to have become more valuable. These bricks are put into the melting-pots, and sometimes a proportion of common salt is thrown in towards the end of the operation, if the vitrification has been imperfect. Under the article *Sulphate of Soda*, in this Dictionary, retained from the old edition, there is the following sentence. "Pajot des Charmes has made some experiments on it in fabricating glass; with sand alone it would not succeed, but equal parts of carbonate of lime, sand, and dried sulphate of soda, produced a clear, solid, pale yellow glass." In the Annals of Philosophy for Jan. 1817, we find the following notice from Schweigger's Journal, xv. 89. : Gehlen, some time before his death, was occupied with experiments on the preparation of glass, by means of sulphate of soda. Professor Schweigger has lately published the result of his trials. He found that the following proportions were the best :—

Sand, . . .	100
Dry sulphate of soda, .	50
Dry quicklime in powder, .	17 to 20
Charcoal, . . .	4

This mixture always gives a very good glass without any addition whatever. During the fusion, the sulphuric acid is decomposed and driven off, and the soda unites with the silica. The sulphate of soda vitrifies very imperfectly, when mixed alone with the silica. The vitrification succeeds better when quicklime is added; and it succeeds completely, when the proportion of charcoal in the formula is added; because the sulphuric acid is thereby decomposed and dissipated. This decomposition may be either effected during the making of the glass, or before, at the pleasure of the workmen.

4. *Broad Glass.* This is made of a mixture of soap-boilers' waste, kelp, and sand. The first ingredient consists of lime used for rendering the alkali of the soap-boiler caustic, the insoluble matter of his kelp or barilla, and a quantity of salt and water, all in a pasty state. The proportions necessarily vary. 2 of the waste, 1 of kelp, and 1 of sand, form a pretty good broad glass. They are mixed together, dried, and fritted.

5. *Bottle Glass* is the coarsest kind. It is made of soaper's waste and river sand, in proportions which practice must determine according to the quantity of the waste; some soap-boilers extracting more saline matter, and other less from their kelps. Common sand and lime, with a little common clay and sea salt, form a cheap mixture for bottle glass.

As far as observation has hitherto directed us, it appears to be a general rule, that the hardness, brittleness, elasticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they assume the solid state. This, which no doubt is referable to the property of crystallization, and its various modes, is remarkably seen in steel and other metals, and seems to obtain in glass. When a drop of glass is suffered to fall into water, it is found to possess the remarkable property of flying into minute pieces, the instant a small part of the tail is broken off. This, which is commonly distinguished by the name of Prince Rupert's drop, is similar to the philosophical phial, which is a small vessel of thick glass suddenly cooled by exposure to the air. Such a vessel possesses the property of flying in pieces when the smallest piece of flint or angular pebble is let fall into it, though a leaden bullet may be dropped into it from some height without injury. Many explanations have been offered, to account for these and other similar appearances, by referring to a supposed mechanism or arrangement of the particles, or sudden confinement of the matter of heat.

The immediate cause, however, appears to be derived from the fact, that the dimensions of bodies suddenly cooled remain larger than if the refrigeration had been more gradual. Thus the specific gravity of steel hardened by sudden cooling in water is less, and its dimensions consequently greater than that of the same steel gradually cooled. It is more than probable, that an effect of the same nature obtains in glass; so that the dimensions of the external and suddenly cooled surface remain larger than are suited to the accurate envelopment of the interior part, which is less slowly cooled. In most of the metals, the degree of flexibility they possess, must be sufficient to remedy this inaccuracy as it takes place; but in glass, which, though very elastic and flexible, is likewise excessively brittle, the adaptation of the parts, urged different ways by their disposition to retain their respective dimensions, and likewise to remain in contact by virtue of the cohesive attraction, can be maintained only by an elastic yielding of the whole, as far as may be, which will therefore remain in a state of tension. It is not therefore to be wondered at that a solution of continuity of any part of the surface should destroy this equilibrium of elasticity; and that the sudden action of all the parts at once of so brittle a material should destroy the continuity of the whole, instead of producing an equilibrium of any other kind.

Though the facts relating to this disposition of glass too suddenly cooled are numerous and interesting to the philosopher, yet they constitute a serious evil with respect to the uses of this excellent material. The remedy of the glass-maker consists in annealing the several articles, which is done by placing them in a furnace near the furnace of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glass cools very slowly throughout, and is in a great measure free from the defects of glass which has been too hastily cooled.

M. Reaumur was the first who made any direct experiments upon the conversion of glass into porcelain. Instances of this effect may be observed among the rubbish of brick-kilns, where pieces of green bottles are not unfrequently subjected by accident to the requisite heat; but the direct process is as follows: A vessel of green glass is to be filled up to the top with a mixture of white sand and gypsum, and then set in a large crucible upon a quantity of the same mixture, with which the glass vessels must also be surrounded and covered over, and the whole pressed down rather hard. The crucible is then to be covered with a lid, the junctures well luted, and put into a potter's kiln, where it must remain during the whole time that the pottery is baking, after which the glass vessel will be found transformed into a milk-white porcelain. The glass, on fracture, appears fibrous, as if it were composed merely of silken threads laid by the side of each other: it has also quite lost the smooth and shining appearance of glass, is very hard, and emits sparks of fire when struck with steel, though not so briskly as real porcelain. Lewis observed that the above-mentioned materials have not exclusively this effect upon glass; but that powdered charcoal, soot, tobacco-pipe clay, and bone-ashes, produce the same change. It is remarkable that the surrounding sand becomes in some measure agglutinated by this process, which, if continued for a sufficient length of time, entirely destroys the texture of the glass, and renders it pulverulent.

The ancient stained glass has been much

admired, and beautiful paintings on this substance have been produced of late years. The colours are of the nature of those used in enamelling, and the glass should have no lead in its composition. M. Brogniart has made many experiments on this subject. The purple of Cassius, mixed with six parts of a flux composed of borax and glass made with silex and lead, produces a very beautiful violet, but liable to turn blue. Red oxide of iron, prepared by means of the nitric acid and subsequent exposure to fire, and mixed with a flux of borax, sand, and a small portion of minium, produces a fine red. Muriate of silver, oxide of zinc, white clay, and the yellow oxide of iron, mixed together without any flux, produce a yellow, light or deep, according to the quantity laid on, and equal in beauty to that of the ancients. A powder remains on the surface after baking, which may easily be cleaned off. Blue is produced by oxide of cobalt, with a flux of silex, potash, and lead. To produce a green, blue must be put on one side of the glass, and yellow on the other; or a blue may be mixed with yellow oxide of iron. Black is made by a mixture of blue with the oxides of manganese and iron.

The bending of the glass, and alteration of the colours in baking, are particularly to be avoided, and require much care. Gypsum has been recommended for their support, but this frequently renders the glass white, and cracked in all directions, probably from the action of the hot sulphuric acid on the alkali in the glass. M. Brogniart placed his plates of glass, some of them much larger than any ever before painted, on very smooth plates of earth or porcelain unglazed, which he found to answer extremely well.

GLAUBER SALT. Native sulphate of soda. Its colours are greyish and yellowish-white. It occurs in mealy efflorescences, prismatic crystals, and imitative shapes. Lustre vitreous. Cleavage threefold. Fracture conchoidal. Soft. Brittle. Sp. gr. 2·2 to 2·3. Taste at first cooling, then saline and bitter. Its solution does not, like that of Epsom salt, afford a precipitate with an alkali. Its constituents are, sulphate of soda 67; carbonate of soda 16½; muriate of soda 11; carbonate of lime 5·64. It occurs along with rock salt and Epsom salt, on the borders of salt lakes, and dissolved in the waters of lakes and the ocean; in efflorescences on moorish ground; also on sandstone, marl-slate, and walls. It is found at Eger in Bohemia, on meadow-ground, as an efflorescence, and in galleries of mines in several places.—*Jameson.*

GLAUBERITE. Colours greyish-white, and wine-yellow. Crystallized in very low oblique four-sided prisms, the lateral edges of which are 104° 28′, and 75° 32′. Lateral planes tranversely streaked: terminal planes smooth. Shining. Fracture foliated or conchoidal. Softer than calcareous spar. Transparent. Brittle. Sp. gr. 2·7. It decrepitates before the blowpipe, and melts into white enamel. In water it becomes opaque, and is partly soluble. Its constituents are, dry sulphate of lime 49; dry sulphate of soda 51. It is found imbedded in rock salt, at Villaruba, near Ocana, in New Castile in Spain.—*Jameson.*

GLAZING. See POTTERY.

GLIMMER. A name occasionally applied to micaceous earths.

GLIADINE. See GLUTEN.

GLUCINA. This earth was discovered by Vauquelin, first in the aqua marina, and afterward in the emerald, in the winter of 1798. Its name is derived from its distinguishing character of forming with acids salts that are sweet to the taste. The following is his method of obtaining it:—

Let 100 parts of beryl or emerald be reduced to a fine powder, and fused in a silver crucible with 300 of pure potash. Let the mass be diffused in water, and dissolved by adding muriatic acid. Evaporate the solution, taking care to stir it toward the end: mix the residuum with a large quantity of water, and filter, to separate the silex. Precipitate the filtered liquor which contains the muriates of alumina and glucina, with carbonate of potash; wash the precipitate, and dissolve it in sulphuric acid. Add a certain quantity of sulphate of potash, evaporate, and crystals of alum will be obtained. When no more alum is afforded by adding sulphate of potash and evaporating, add solution of carbonate of ammonia in excess, shake the mixture well, and let it stand some hours, till the glucina is redissolved by the excess of carbonate of ammonia, and nothing but the alumina remains at the bottom of the vessel. Filter the solution, evaporate to dryness and expel the acid from the carbonate of glucina, by slight ignition in a crucible. Thus 15 or 16 per cent. of pure glucina will be obtained.

Glucina thus obtained is a white, soft powder, light, insipid, and adhering to the tongue. It does not change vegetable blues. It does not harden, shrink, or agglutinate by heat; and is infusible. It is insoluble in water, but forms with it a slightly ductile paste. It is dissolved by potash, soda, and carbonate of ammonia; but not by pure ammonia. It unites with sulphuretted hydrogen. Its salts have a saccharine taste, with somewhat of astringency. See SALT.

Sir H. Davy's researches have rendered it more than probable, that glucina is a compound of oxygen, and a peculiar metallic substance, which may be called *glucinum*. By heating it along with potassium, the latter was converted for the most part into potash; and dark coloured particles, having a metallic appearance, were found diffused through the mass, which regained the earthy character by being heated in the air, and by the action of water. In this last case, hydrogen was slowly disengaged.

According to Sir H. Davy, the prime equivalent of glucina would be 3.6 on the oxygen scale, and that of glucinum 2.6. These are very nearly the equivalents of lime and calcium. From the composition of the sulphate, Berzelius infers the equivalent to be 3.2, and that of its basis 2.2.

GLUE. An inspissated jelly made from the parings of hides and other offals, by boiling them in water, straining through a wicker basket, suffering the impurities to subside, and then boiling it a second time. The articles should first be digested in lime water, to cleanse them from grease and dirt; then steeped in water, stirring them well from time to time; and lastly, laid in a heap, to have the water pressed out, before they are put into the boiler. Some recommend, that the water should be kept as nearly as possible to a boiling heat, without suffering it to enter into ebullition. In this state it is poured into flat frames or moulds, then cut into square pieces when congealed, and afterward dried in a coarse net. It is said to improve by age; and that glue is reckoned the best, which swells considerably without dissolving by three or four days' infusion in cold water, and recovers its former dimensions and properties by drying.

Shreds or parings of vellum, parchment, or white leather, make a clear and almost colourless glue.

GLUTEN (VEGETABLE). If wheat-flour be made into a paste, and washed in a large quantity of water, it is separated into three distinct substances: a mucilaginous saccharine matter, which is readily dissolved in the liquor, and may be separated from it by evaporation; starch, which is suspended in the fluid, and subsides to the bottom by repose; and gluten, which remains in the hand, and is tenacious, very ductile, somewhat elastic, and of a brown-grey colour. The first of these substances does not essentially differ from other saccharine mucilages. The second, namely, the starch, forms a gluey fluid by boiling in water, though it is scarcely, if at all, acted upon by that fluid when cold. Its habitudes and products with the fire, or with nitric acid, are nearly the same as those of gum and of sugar. It appears to be as much more remote from the saline state than gum, as gum is more remote from that state than sugar.

The vegetable gluten, though it existed before the washing in the pulverulent form, and has acquired its tenacity and adhesive qualities from the water it has imbibed, is nevertheless totally insoluble in this fluid. It has scarcely any taste. When dry, it is semitransparent, and resembles glue in its colour and appearance. If it be drawn out thin, when first obtained, it may be dried by exposure to the air; but if it be exposed to warmth and moisture while wet, it putrefies like an animal substance. The dried gluten applied to the flame of a candle, crackles, swells, and burns, exactly like a feather, or piece of horn. It affords the same products by destructive distillation as animal matters do; is not soluble in alcohol, oils, or ether; and is acted upon by acids and alkalis, when heated. According to Rouelle, it is the same with the caseous substance of milk.

Gluten of Wheat.—M. Taddey, an Italian chemist, has lately ascertained that the gluten of wheat may be decomposed into two principles, which he has distinguished by the names, *gliadine* (from γλια, gluten), and *zimome* (from ζυμη, ferment). They are obtained in a separate state by kneading the fresh gluten in successive portions of alcohol, as long as that liquid continues to become milky, when diluted with water. The alcohol solutions being set aside, gradually deposit a whitish matter, consisting of small filaments of gluten, and become perfectly transparent. Being now left to slow evaporation, the gliadine remains behind, of the consistence of honey, and mixed with a little yellow resinous matter, from which it may be freed by digestion in sulphuric ether, in which gliadine is not sensibly soluble. The portion of the gluten not dissolved by the alcohol is the *zimome*.

Properties of Gliadine.—When dry, it has a straw-yellow colour, slightly transparent, and in thin plates, brittle, having a slight smell, similar to that of honeycomb, and, when slightly heated, giving out an odour similar to that of boiled apples. In the mouth, it becomes adhesive, and has a sweetish and balsamic taste. It is pretty soluble in boiling alcohol, which loses its transparency in proportion as it cools, and then retains only a small quantity in solution. It forms a kind of varnish on those bodies to which it is applied. It softens, but does not dissolve in cold distilled water. At a boiling heat it is converted into froth, and the liquid remains slightly milky. It is specifically heavier than water.

The alcoholic solution of gliadine becomes milky when mixed with water, and is precipitated in white flocks by the alkaline carbonates. It is scarcely affected by the mineral and vegetable acids. Dry gliadine dissolves in caustic alkalis and in acids. It swells upon red-hot coals, and then contracts in the manner of animal substances. It burns with a pretty lively flame, and leaves behind it a light spongy charcoal, difficult to incinerate. Gliadine, in some respects, approaches the properties of resins; but differs from them in being insoluble in sulphuric ether. It is very sensibly affected by the infusion of nut-galls. It is capable of itself of undergoing a slow fermentation, and produces fermentation in saccharine substances.

From the flour of barley, rye, or oats, no gluten can be extracted, as from that of wheat, probably because they contain too small a quantity. See ZIMOME.

GNEISS. A compound rock, consisting of felspar, quartz, and mica, disposed in slates, from the predominance of the mica scales. Its structure is called by Werner, granular-slaty. This geognostic formation is always stratified; contains sometimes crystals of schorl, tourmaline, and garnet, and is peculiarly rich in metallic ores.

GOLD is a yellow metal, of specific gravity 19.3. It is soft, very tough, ductile, and malleable; unalterable and fixed, whether exposed to the atmosphere, or to the strongest heat of furnaces. Powerful burning mirrors have volatilized it; and it has been driven up in fumes, in the metallic state, by flame urged upon it by a stream of oxygen gas. The electric shock converts it into a purple oxide, as may be seen by transmitting that commotion through gold leaf, between two plates of glass; or by causing the explosive spark of three or more square feet of coated glass, to fall upon a gilded surface. A heat of 32° *W.* or perhaps 1300° F. is required to melt it, which does not happen till after ignition. Its colour when melted, is of a bluish-green; and the same colour is exhibited by light transmitted through gold leaf.

The limits of the ductility and malleability of gold are not known.

The method of extending gold used by the gold-beaters consists in hammering a number of thin rolled plates between skins or animal membranes. By the weight and measure of the best wrought gold leaf, it is found, that one grain is made to cover 56¾ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows, that the leaf itself is $\frac{1}{282000}$ part of an inch thick. This, however, is not the limit of the malleability of gold; for the gold-beaters find it necessary to add three grains of copper in the ounce to harden the gold, which otherwise would pass round the irregularities of the newest skins, and not over them; and in using the old skins, which are not so perfect and smooth, they proceed so far as to add twelve grains. The wire which is used by the lace-makers is drawn from an ingot of silver, previously gilded. In this way, from the known diameter of the wire, or breadth when flattened, and its length, together with the quantity of gold used, it is found, by computation, that the covering of gold is only one 12th part of the thickness of gold-leaf, though it still is so perfect as to exhibit no cracks when viewed by a microscope.

No acid acts readily upon gold but aqua regia, and aqueous chlorine. Chromic acid added to the muriatic enables it to dissolve gold.

The small degree of concentration of which aqueous chlorine is susceptible, and the imperfect action of the latter acids, render aqua regia the most convenient solvent for this metal.

When gold is immersed in aqua regia, an effervescence takes place; the solution tinges animal matters of a deep purple, and corrodes them. By careful evaporation, fine crystals of a topaz colour are obtained. The gold is precipitated from its solvent, by a great number of substances. Lime and magnesia precipitate it in the form of a yellowish powder. Alkalis exhibit the same appearance; but an excess of alkali redissolves the precipitate. The precipitate of gold obtained from aqua regia by the addition of a fixed alkali appears to be a true oxide, and is soluble in the sulphuric, nitric, and muriatic acids; from which, however, it separates by standing, or by evaporation of the acids. Gallic acid precipitates gold of a reddish colour, very soluble in the nitric acid, to which it communicates a fine blue colour.

Ammonia precipitates the solution of gold much more readily than fixed alkalis. This precipitate, which is of a brown, yellow, or orange colour, possesses the property of detonating with a very considerable noise when gently heated. It is known by the name of fulminating gold. The presence of ammonia is necessary to give the fulminating property to the precipitate of gold; and it will be produced by precipitating it with fixed alkali, from an aqua regia previously made by adding sal ammoniac to nitric acid; or by precipitating the gold from pure aqua regia, by means of sal ammonia, instead of the ammonia alone. The fulminating gold weighs one-fourth more than the gold made use of. A considerable degree of precaution is necessary in preparing this substance. It ought not to be dried but in the open air, at a distance from a fire, because a very gentle heat may cause it to explode. Several fatal accidents have arisen from its explosion, in consequence of the friction of ground stoppers in bottles containing this substance, of which a small portion remained in the neck.

Fulminating gold, when exposed by Berthollet to a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of its fulminating quality, and converted into an oxide at the same time that ammoniacal gas was disengaged. From this dangerous experiment it is ascertained, that fulminating gold consists of oxide of gold combined with ammonia. The same eminent philosopher caused fulminating gold to explode in copper vessels. Nitrogen gas was disengaged, a few drops of water appeared, and the gold was reduced to the metallic form. In this experiment he infers, that the ammonia was decomposed; that the nitrogen, suddenly assuming the elastic state, caused the explosion, while the oxygen of the oxide united with the hydrogen of the alkali, and formed the water.

This satisfactory theory was still farther confirmed by the decomposition of fulminating gold, which takes place in consequence of the action of the concentrated sulphuric acid, of melted sulphur, fat oils, and ether; all which deprived it of its fulminating quality, by combining with its ammonia.

Sulphurets precipitate gold from its solvent, the alkali uniting with the acid, and the gold falling down combined with the sulphur; of which, however, it may be deprived by moderate heat.

Most metallic substances precipitate gold from aqua regia: lead, iron, and silver, precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic state; bismuth, zinc, and mercury, likewise precipitate it. A plate of tin, immersed in a solution of gold, affords a purple powder, called the purple powder of Cassius, which is used to paint in enamel.

Ether, naphtha, and essential oils, take gold from its solvent, and from liquors, which have been called potable gold. The gold which is precipitated by evaporation of these fluids, or by the addition of sulphate of iron to the solution of gold, is of the utmost purity.

Most metals unite with gold by fusion. With silver it forms a compound, which is paler in proportion to the quantity of silver added. It is remarkable, that a certain proportion, for example a fifth part, renders it greenish. From this circumstance, as well as from that of a considerable proportion of these metals separating from each other by fusion, in consequence of their different specific gravities, when their proportions do not greatly differ, it should seem that their union is little more than a mere mixture without combination; for, as gold leaf transmits the green rays of light, it will easily follow, that particles of silver, enveloped in particles of gold, will reflect a green instead of a white light.

A strong heat is necessary to combine platina with gold: it greatly alters the colour of the gold, if its weight exceed the forty-seventh part of the mass.

Mercury is strongly disposed to unite with gold, in all proportions, with which it forms an amalgam: this, like other amalgams, is softer the larger the proportion of mercury. It softens and liquefies by heat, and crystallizes by cooling.

Lead unites with gold, and considerably impairs its ductility, one-fourth of a grain to an ounce rendering it completely brittle. Copper renders gold less ductile, harder, more fusible, and of a deeper colour. This is the usual addition in coin, and other articles used in society. Tin renders it brittle in proportion to its quantity; but it is a common error of chemical writers to say, that the slightest addition is sufficient for this purpose. When alloyed with tin, however, it will not bear a red heat. With iron it forms a grey mixture, which obeys the magnet. This metal is very hard, and is said to be much superior to steel for the fabrication of cutting instruments. Bismuth renders gold white and brittle; as do likewise nickel, manganese, arsenic, and antimony. Zinc produces the same effect; and, when equal in weight to the gold, a metal of a fine grain is produced, which is said to be well adapted to form the mirrors of reflecting telescopes, on account of the fine polish it is susceptible of, and its not being subject to tarnish. The alloys of gold with molybdena are not known. It could not be mixed with tungsten, on account of the infusibility of this last substance. Mr. Hatchett gives the following order of different metals, arranged as they diminish the ductility of gold: bismuth, lead, antimony, arsenic, zinc, cobalt, manganese, nickel, tin, iron, platina, copper, silver. The first three were nearly equal in effect; and the platina was not quite pure.

For the purposes of coin, Mr. Hatchett considers an alloy of equal parts of silver and copper as to be preferred, and copper alone as preferable to silver alone.

The peroxide of gold thrown down by potash, from a solution of the neutral muriate, consists, according to Berzelius, of 100 gold and 12 oxygen. It is probably a tritoxide. The protoxide of a greenish colour, is procured by treating with potash water muriate of gold, after heat has expelled the chlorine. It seems to consist of 100 metal + 4 oxygen. The prime equivalent of gold comes out apparently 25.

The gold coins of Great Britain contain eleven parts of gold, and one of copper. See Assay, Gilding, and Ores of Gold.

GONG, or TAM-TAM, of the Chinese; a species of cymbal which produces a very loud sound on being struck. It is an alloy, according to M. Thenard's analysis, of about 80 parts of copper and 20 of tin.

GONIOMETER. An instrument for measuring the angles of crystals. See Crystallization.

GORGONIA NOBILIS. The red coral. It consists of an interior stem, composed of gelatinous matter and carbonate of lime, with a cortex, consisting of membrane with carbonate of lime, coloured by some unknown substance.

GOULARD'S EXTRACT. A saturated solution of subacetate of lead. See Lead.

GOUTY CONCRETIONS. These have been called chalk-stones from their appearance; but Dr. Wollaston first demonstrated their true composition to be uric acid combined with ammonia, and thus explained the mysterious pathological relation between gout and gravel. See Calculus (Urinary).

Gouty concretions are soft and friable. They are insoluble in cold, but slightly in boiling water. An acid being added to this solution, seizes the soda, and the uric acid is deposited in small crystals. These concretions dissolve readily in water of potash. An artificial compound may be made by triturating uric acid and soda with warm water, which exactly resembles gouty concretions in its chemical constitution.

GRAINER. The lixivium obtained by infusing pigeons' dung in water, is used for giving flexibility to skins in the process of tanning, and is called the grainer.

GRAMMATITE. See TREMOLITE.

GRANATITE. See GRENATITE.

GRANITE. A compound rock, consisting of quartz, felspar, and mica, each crystallized and cohering by mutual affinity, without any basis or cement. The felspar commonly predominates, and the mica is in smallest quantity. The colours of the felspar are white, red, grey, and green. The quartz is light grey, and the mica dark. The granular crystals vary exceedingly in size, in different granite rocks. Occasionally granite is stratified; but sometimes no stratification can be perceived. Large globular masses, called rolling stones, are frequently met with, composed each of concentric lamellar concretions. Schorl, garnet, and tinstone, are frequently present in granite. Tin and iron are the only metals abundantly found in this rock. It contains molybdena, silver, copper, lead, bismuth, arsenic, titanium, tungsten, and cobalt. It is, however, poorer in ores than many other rock formations.

GRANULATION. The method of dividing metallic substances into grains or small particles, in order to facilitate their combination with other substances, and sometimes for the purpose of readily subdividing them by weight.

This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of congelation, at which instant it becomes converted into a powder.

Various contrivances are used to prevent danger, and ensure success, in the several manufactories that require granulation. Copper is granulated for making brass, by pouring it through a perforated ladle into a covered vessel of water with a moveable false bottom. A compound metal, consisting chiefly of lead, is poured into water through a perforated vessel of another kind, for making small shot, in which the height above the surface of the fluid requires particular adjustment. In a new manufactory of this kind, the height is upward of 100 feet.

GRAPHIC ORE. An ore of tellurium, occurring in veins in porphyry in Transylvania. It consists, in 100 parts, of 60 tellurium, 30 gold, and 10 silver, by Klaproth.

GRAPHITE. Rhomboidal graphite of Jameson, or plumbago, of which he gives two sub-species, the scaly and compact.

1st, *Scaly Graphite.* Colour dark steel-grey, approaching to iron-black. It occurs massive, disseminated and crystallized. The primitive form is a rhomboid. The secondary form is the equiangular six-sided table. Lustre splendent, metallic. Cleavage single. Fracture scaly foliated. Streak shining and metallic. Hardness sometimes equal to that of gypsum.

Perfectly sectile. Rather difficultly frangible. It writes and soils. Streak on paper black. Feels very greasy. Sp. gr. from 1.9 to 2.4.

2d, *Compact Graphite.* Colour rather blacker than preceding. Massive, disseminated, and in columnar concretions. Internal lustre glimmering and metallic. Fracture small grained uneven, passing into conchoidal. When heated in a furnace, it burns without flame or smoke, forming carbonic acid, and leaving a residuum of iron. Its constituents are, carbon 91, iron 9.—*Berthollet.* It sometimes contains nickel, chromium, manganese, and oxide of titanium. It usually occurs in beds, sometimes disseminated and in imbedded masses, in granite, gneiss, mica-slate, clay-slate, foliated granular limestone, coal and trap formations. It is found in gneiss in Glen Strath Farrar in Inverness-shire; in the coal formation near Cumnock in Ayrshire, where it is imbedded in greenstone, and in columnar glance-coal. At Borrodale in Cumberland, it occurs in beds of very varying thickness, included in a bed of trap, which is subordinate to clay-slate; and in many places on the continent, and elsewhere. The finer kinds are first boiled in oil, and then cut into tables for pencils. Grates are blackened with it, and crucibles formed of a mixture of it and clay.—*Jameson.*

GRAVEL. See CALCULUS (URINARY).

GRAVITY, a term used by physical writers to denote the cause by which all bodies move toward each other, unless prevented by some other force or obstacle. See ATTRACTION.

GRAVITY (SPECIFIC). See SPECIFIC GRAVITY.

For the specific gravities of different kinds of elastic fluids, see the table at the article GAS.

GREEK FIRE. Asphaltum is supposed to have been its chief constituent, along with nitre and sulphur.

GREEN-EARTH. Colour celadine-green, and green of darker shades. Massive, and in globular and amygdaloidal shaped pieces, sometimes hollow, or as incrusting agate balls. Dull. Fracture earthy. Opaque. Feebly glistening in the streak. Soft and sectile. Rather greasy. Adheres slightly to the tongue. Sp. gr. 2.6. Before the blowpipe it is converted into a black vesicular slag.

Its constituents are, silica 53, oxide of iron 28, magnesia 2, potash 10, water 6. It is a frequent mineral in the amygdaloid of Scotland, England, Ireland, Iceland, and the Faroe Islands. It occurs in Saxony, near Verona, the Tyrol, and Hungary. It is the *mountain-green* of artists in water colours. Its colour is durable, but not so bright as that from copper. The *green-earth* of Verona, of which the analysis is given above, is most esteemed.—*Jameson.*

GREENSTONE. A rock of the *trap* formation, consisting of hornblende and felspar, both in the state of grains or small crystals. The hornblende is commonly most abundant, and communicates a green tinge to the felspar. This rock is called *Diabase* by the French geologists, who name the compact greenstone *Aphanite.*

GREEN VITRIOL. Sulphate of iron.

GRENATITE. Prismatoidal garnet; the staurotide of Haüy.

GRENATITE, or prismatic garnet. See STAUROTIDE.

GREYWACKE. A mountain formation, consisting of two similar rocks, which alternate with, and pass into each other, called greywacke, and greywacke-slate. The first possesses the characters of the formation. It is a rock composed of pieces of quartz, flinty-slate, felspar, and clay-slate, cemented by a clay-slate basis. These pieces vary in size from a hen's egg to little grains. When the texture becomes exceedingly fine grained, the rock constitutes greywacke-slate. Its colour is usually ash or smoke-grey, without the yellowish-grey, or greenish tinge, frequent in primitive slate. It has not the continuous lustre of primitive slate, but glimmers from interspersed scales of mica. It contains quartz veins, but no beds of quartz. Petrifactions are found in it. These rocks are stratified, forming, when alone, round-backed hills, with deep valleys between them. Immense beds of trap, flinty-slate, and transition limestone, are contained in this formation; as well as numerous metallic ores in beds and large veins.

GROSSULARE. Colour asparagus-green. Crystallizes in acute double eight-sided pyramids, flatly acuminated on both extremities by four planes; the acuminating planes set on the alternate edges of the double eight-sided pyramid. Planes of the crystals smooth, shining. Fracture between conchoidal and uneven. Translucent. Brittle. Occurs imbedded in small crystals along with vesuvian, in a pale greenish-grey clay-stone near the river Wilui, in Siberia—also at the Bannat of Temeswar.—*Jameson.*

GUAIACUM. A resinous looking substance, extracted from the very dense wood of a tree growing in the West Indies, called *guaiacum officinale.*

It differs however from resins in its habitudes with nitric acid, as Mr. Hatchett first showed. Its sp. gr. is 1.229. Its colour is yellowish-brown, but it becomes green on exposure to light. It is transparent, and breaks with a resinous fracture. Its odour is not disagreeable, but when a very little of its powder, mixed with water, is swallowed, it excites a very unpleasant burning sensation in the fauces and stomach. Heat fuses it, with the exhalation of a somewhat fragrant smell.

Water dissolves a certain portion of it, acquiring a brownish tinge, and sweetish taste. The soluble matter is left when the water is evaporated. It constitutes 9 per cent. of the whole, and resembles what some chemists call extractive.

Guaiacum is very soluble in alcohol. This solution, which is brown-coloured, is decomposed by water. Aqueous chlorine throws down a pale blue precipitate from it.

Guaiacum dissolves readily in alkaline leys, and in sulphuric acid; and in the nitric with effervescence. From the solution in the last liquid, oxalic acid may be procured by evaporation, but no artificial tannin can be obtained, as from the action of nitric acid on the other resins.

Guaiacum, distilled in close vessels, leaves 30.5 per cent. of charcoal, being nearly double the quantity from an equal weight of the common resins. From Dr. Wollaston's experiments, it would appear that both air and light are necessary to produce the change in guaiacum from yellow to green. And Mr. Brande found that this green colour was more rapidly brought on in oxygen, than in common air. With nitric acid, or chlorine, it becomes green, next blue, and lastly brown.

By my analysis Guaiacum is composed, in 100 parts, of carbon 67.88, hydrogen 7.05, oxygen 25.07; or, approximately,

Carbon	7 atoms	5.25	67.7
Hydrogen	4	0.50	6.5
Oxygen	2	2.00	25.8
		7.75	100.0

Formerly guaiacum was much commended in syphilis and other complaints; at present it is used chiefly in rheumatism, dissolved in liquid ammonia.

GUANO. A substance found on many of the small islands in the South Sea, which are the resort of numerous flocks of birds, particularly of the ardea and phœnicopteros genus. It is dug from beds 50 or 60 feet thick, and used as a valuable manure in Peru, chiefly for Indian corn. It is of a dirty yellow colour, nearly insipid to the taste, but has a powerful smell partaking of castor and valerian. According to the analysis of Fourcroy and Vauquelin, about one-fourth of it is uric acid, partly saturated with ammonia and lime. It contains likewise oxalic acid, partly saturated with ammonia and potash; phosphoric acid combined with the same bases and with lime; small quantities of sulphate and muriate of potash, and ammonia; a small portion of fat matter; and sand, partly quartzose, partly ferruginous.

GUM. The mucilage of vegetables. The principal gums are, 1. The common gums, obtained from the plum, the peach, the cherry tree, &c.—2. Gum Arabic, which flows naturally from the acacia in Egypt, Arabia, and elsewhere. This forms a clear transparent mucilage with water.—3. Gum Seneca, or Senegal. It does not greatly differ from gum Arabic; the pieces are larger and clearer; and it seems to communicate a higher degree of the adhesive quality to water. It is much used by calico-printers and others. The first sort of gums are frequently sold by this name, but may be known by their darker colour.—4. Gum Adragant or Tragacanth. It is obtained from a small plant of the same name growing in Syria, and other eastern parts. It comes to us in small white contorted pieces resembling worms. It is usually dearer than other gums, and forms a thicker jelly with water.

Mr. Willis has found, that the root of the common blue-bell, *hyacinthus non scriptus*, dried and powdered, affords a mucilage possessing all the qualities of that from gum Arabic. Lord Dundonald has extracted a mucilage also from lichens.

Gums treated with nitric acid afford the acid of sugar.

I found Gum Arabic to consist of carbon 35.13, hydrogen 6.08, oxygen 55.79, azote 3?

GUM (ELASTIC). See CAOUTCHOUC.

GUM RESIN. The principal gum resins are frankincense, scammony, asafœtida, aloes, gum ammoniac, and gamboge.

GUNPOWDER. This well known powder is composed of 75 parts, by weight, of nitre, 16 of charcoal, and 9 of sulphur, intimately blended together by long pounding in wooden mortars, with a small quantity of water. This proportion of the materials is the most effectual. But the variations of strength in different samples of gunpowder are generally occasioned by the more or less intimate division and mixture of the parts. The reason of this may be easily deduced from the consideration, that nitre does not detonate until in contact with inflammable matter; whence the whole detonation will be more speedy, the more numerous the surfaces of contact. The same cause demands, that the ingredients should be very pure, because the mixture of foreign matter not only diminishes the quantity of effective ingredients which it represents, but likewise prevents the contacts by its interposition.

The nitre of the third boiling is usually chosen for making gunpowder, and the charcoal of light woods is preferred to that of those which are heavier, most probably because this last, being harder, is less pulverable.

The requisite pounding of the materials is performed in the large way by a mill, in which wooden mortars are disposed in rows, and in each of which a pestle is moved by the arbor of a water-wheel: it is necessary to moisten the mixture from time to time with water, which serves to prevent its being dissipated in the pulverulent form, and likewise obviates the danger of explosion from the heat occasioned by the blows. Twelve hours' pounding is in general required to complete the mixture; and when this is done, the gunpowder is in fact made, and only requires to be dried to render it fit for use.

The granulation of gunpowder is performed by placing the mass, while in the form of a stiff paste, in a wire sieve, covering it with a board, and agitating the whole: by this means it is cut into small grains or parts, which, when of a requisite dryness, may be rendered smooth or glossy by rolling them in a cylindrical vessel or cask. Gunpowder in this form takes fire more speedily than if it be afterward reduced to powder, as may be easily accounted for from the circumstance, that the inflammation is more speedily propagated through the interstices of the grains. But the process of granulation does itself, in all probability, weaken the gunpowder, in the same manner as it is weakened by suffering it to become damp; for, in this last case, the nitre, which is the only soluble ingredient, suffers a partial solution in the water, and a separation in crystals of greater or less magnitude; and accordingly the surfaces of contact are rendered less numerous.

Berthollet found, that the elastic product afforded by the detonation of gunpowder, consisted of two parts nitrogen gas, and one carbonic acid gas. The sudden extrication and expansion of these airs are the cause of the effects of gunpowder.

GURHOFITE. *Compact Dolomite*, which occurs in veins in serpentine rocks, between Gurhof and Aggsbach, in Lower Austria.

GYPSUM. This genus contains 2 species, by Professor Jameson; the prismatic, and the axifrangible.

I.—*Prismatic gypsum* or *anhydrite*. *Muriacit.*—Werner. Of this there are 5 subspecies.

1. *Sparry anhydrite*. See *Cube*-SPAR.

2. *Scaly anhydrite*. Colour white of various shades passing into smalt-blue. Massive, and in granular concretions. Lustre splendent, pearly. Cleavage imperfect and curved. Translucent on the edges. Easily broken. Sp. gr. 2·96. Its constituents are, lime 41·75, sulphuric acid 55, mur. of soda 1·0. It is found in the salt mines of the Tyrol, 5088 feet above the level of the sea.

3. *Fibrous anhydrite*. Colours, red, blue, and grey. Massive, and in coarse fibrous concretions. Lustre glimmering and pearly. Translucent on the edges. Rather easily frangible. Spec. grav. 3. It is found in the

salt mines on the continent. The blue is sometimes cut into ornaments.

4. *Convoluted anhydrite.* Colour, dark milk-white. Massive, and in distinct concretions. Lustre glimmering and pearly. Fracture fine splintery. Translucent on the edges. Sp. gr. 2·85. Its constituents are, 42 lime, 56·5 sulphuric acid, 0·25 muriate of soda. It occurs in the salt mines of Bochnia, and at Wieliczka in Poland. It has been called *pierre de tripes*, from its convoluted concretions.

5. *Compact anhydrite.* Colour grey, sometimes with spotted delineations. Massive, and in distinct granular concretions. Feebly glimmering. Fracture small splintery. Translucent. Hardness and constituents as in the preceding. Sp. gr. 2·95.

II.—*Axifrangible gypsum.*

This species contains, according to Professor Jameson, 6 sub-species; sparry gypsum, foliated, compact, fibrous, scaly foliated, and earthy gypsum.

1. *Sparry gypsum* or *selenite.* Colours, grey, white, and yellow, with occasional iridescence. Massive, disseminated, and crystallized. Its primitive form is an oblique four-sided prism, with angles of 113° 8′ and 66° 52′. The following are some of the secondary forms. 1. Six-sided prism, generally broad, and oblique angular, and four smaller lateral planes. 2. Lens. 3. Twin crystals, formed either by two lenses, or by two six-sided prisms, pushed into each other in the direction of their breadth. 4. Quadruple crystal, from two twin crystals pushed into each other in the direction of their length. Lustre splendent, pearly. Cleavage threefold. Fragments rhomboidal. Semitransparent, and transparent. Refracts double. Yields to the nail. Scratches talc, but not calcareous spar. Sectile. Easily frangible. In thin pieces flexible, but inelastic. Sp. gr. 2·3. It exfoliates and melts into a white enamel, which falls into a white powder. Its constituents are, 33·9 lime, 43·9 sulphuric acid, 21 water, and 2·1 loss; *Bucholz.* It occurs principally in the floetz gypsum formation in thin layers; less frequently in rock salt; frequently in the London blue clay. Crystals are daily forming in gypsum hills, and in old mines. It is found in blue clay, at Shotover-hill, near Oxford; Newhaven, Sussex; around Paris, and all over the continent. It was used in ancient times for window glass. Hence it was called glacies mariæ, and lapis specularis.

2. *Foliated granular gypsum.* Colours, white, grey, and red; sometimes in spotted or striped delineations. Massive, and in distinct concretions, or crystallized, in small conical lenses. Lustre, glistening, pearly. Cleavage as selenite. Translucent. Very soft, sectile, and easily frangible. Sp. gr. 2·3. Its constituents are, 32 lime, 30 sulphuric acid, and 38 water, according to Kirwan. It occurs in beds in primitive rocks, as gneiss and mica-slate; in transition clay-slate; but most abundantly in beds in the rocks of the floetz class. It is there associated with selenite, compact gypsum, fibrous gypsum, rock-salt, stinkstone, and limestone. It is found in Cheshire and Derbyshire, at Lüneburg, and other places on the continent. The foliated and compact gypsums, when pure and capable of receiving a good polish, are termed *alabaster* by artists, who fashion them into statues and vases. The coarser kinds are used in small quantities in agriculture; and are converted by calcination into stucco.

3. *Compact gypsum.* Colours, white of various shades, grey, blue, red, and yellow. Massive. Dull. Fracture fine splintery. Translucent on the edges. Soft, sectile, and easily frangible. Sp. gr. 2·2. Its constituents are, 34 lime, 48 sulphuric aid, 18 water.—*Gerhard.* It occurs in beds, along with granular gypsum, &c. It is found in the Campsie hills; in Derbyshire; at Ferrybridge, Yorkshire, and in various places on the Continent.

4. *Fibrous gypsum.* Colours white, grey, and red. Massive and dentiform, and in fibrous distinct concretions. Lustre glistening and pearly. Translucent. Soft, sectile, and easily frangible. Its constituents are, 33 lime, 44·13 sulphuric acid, 21 water. It occurs along with the other sub-species, in red sandstone near Moffat; in the Forth river near Belfast; in Cumberland, Yorkshire, Cheshire, &c. When cut *en cabachon*, and polished, it reflects a light, not unlike that of the cat's-eye, and is sometimes sold as that stone.

5. *Scaly foliated gypsum.* Colour white. Massive, disseminated, and in distinct concretions. Lustre, glistening and pearly. Fracture small scaly foliated. Opaque, or translucent on the edges. Soft, passing into friable. Sectile and easily frangible. It occurs along with selenite, at Montmartre, near Paris, in the third floetz formation of Werner.

6. *Earthy gypsum.* Colour yellowish-white. Composed of fine scaly or dusty particles. Feebly glimmering. Feels meagre or rather fine. Soils slightly. Light. It is found immediately under the soil, in beds several feet thick, resting on gypsum, in Saxony, Switzerland, and Norway.—*Jameson.*

H

HÆMATITES. An ore of iron.

HAIR. From numerous experiments M. Vauquelin infers, that black hair is formed of nine different substances, namely:

1. An animal matter, which constitutes the greater part. 2. A white concrete oil in small quantity. 3. Another oil of a greyish-green colour, more abundant than the former. 4. Iron, the state of which in the hair is uncertain. 5. A few particles of oxide of manganese. 6. Phosphate of lime. 7. Carbonate of lime, in very small quantity. 8. Silex, in a conspicuous quantity. 9. Lastly, a considerable quantity of sulphur.

The same experiments show, that red hair differs from black only in containing a red oil instead of a blackish-green oil; and that white hair differs from both these only in the oil being nearly colourless, and in containing phosphate of magnesia, which is not found in them.

HARMOTOME. Cross-stone.

HARTSHORN (SPIRIT OF). See Ammonia.

HATCHETINE. A variety of bituminous matter found in the iron-stone Merthyr Tydfil, in South Wales. Colour yellowish-white. Texture flaky or subgranular; in the former the lustre is glistening, in the latter dull. Hardness of soft tallow. Inelastic, and inodorous. Melts at 170°. It is very light. Soluble in ether. Hatchetine is found filling small contemporaneous veins, lined with calcareous spar and small rock crystals, in the iron-stone. *Mr. J. J. Conybeare, in Annals of Phil. N. S.* i. 136.

HAUYNE. Colour blue of various shades. It occurs imbedded in grains, and rarely crystallized; in acute oblique double four-sided pyramids, variously truncated. Externally it is generally smooth, and edges rounded. Lustre splendent, to glistening, and vitreous. Cleavage quintuple. Fracture imperfect conchoidal. Transparent and translucent. Harder than apatite, but softer than felspar. Brittle. Easily frangible. Sp. gr. 2·7. It melts with difficulty before the blowpipe, into a white nearly opaque vesicular bead. With borax it melts into a transparent wine-yellow glass. With acids it forms a transparent jelly. Its constituents are, silica 30, alumina 15, lime 13.5, sulphuric acid 12, potash 11, iron 1, loss 17·5.—*Vauquelin.* But by Gmelin, we have silica 35·48, alumina 18·87, lime 11·79, sulphuric acid 12·6, potash 15·45, iron 1·16, loss 3·45. It occurs imbedded in the basalt rock of Albano and Frescati. Professor Jameson thinks it nearly allied to azure-stone.

HEAVY SPAR. Baryte. This genus is divided by Professor Jameson into four species; rhomboidal, prismatic, diprismatic, and axifrangible.

1. *Rhomboidal baryte*, or *Witherite*. Colours white, grey, and yellow. Massive. Disseminated in various imitative shapes, and crystallized. The primitive form is a rhomboid of 88° 6′ and 91° 54′. The secondary forms are, the equiangular six-sided prism, truncated, or acutely acuminated, and the acute double six-sided pyramid. Prisms scopiformly grouped, or in druses. Lustre glistening, and resinous. Cleavage threefold. Principal fracture uneven. Translucent. Harder than calcareous spar. Easily frangible. Sp. gr. 4·3. Before the blowpipe it decrepitates slightly, and melts readily into a white enamel; soluble with effervescence in dilute nitric acid. It is carbonate of barytes, with occasionally 1 per cent. of carbonate of strontites and sulphate of barytes. It occurs in Cumberland and Durham in lead veins that traverse a secondary limestone, which rests on red sandstone. It is an active poison, and is employed for killing rats.

2. *Prismatic baryte*, or *Heavy spar*. Of this there are nine sub-species; earthy, compact, granular, curved lamellar, straight lamellar, fibrous, radiated, columnar, and prismatic. They are all sulphates of barytes in composition. On account of its forms of crystallization, we shall describe the *fresh, straight, lamellar*, heavy spar.

Its colours are white, grey, blue, green, yellow, red, and brown. Massive, in distinct concretions, and crystallized. The primitive form is an oblique four-sided prism of 101° 53′. The following are the secondary forms: the rectangular four-sided table; the oblique four-sided table, perfect or variously truncated or bevelled; the longish six-sided table, perfect or bevelled; the eight-sided table, perfect or bevelled. Lustre splendent, between resinous and pearly. Cleavage parallel with the planes of the primitive prism. Fragments rhomboidal and tabular. Translucent or transparent, and refracts double. Scratches calcareous spar, but is scratched by fluor spar. Brittle. Sp. gr. 4·1 to 4·6. It decrepitates briskly before the blowpipe, and then melts into a white enamel. It phosphoresces on glowing coals with a yellow light. It is sulphate of barytes, with 0·85 sulphate of strontites, and 0·80 oxide of iron. It is found almost always in veins, which occur in granite, gneiss, mica-slate, and other rocks. The flesh-red variety is often accompanied with valuable ores. In Great Britain, it occurs in veins of different primitive and transition rocks, and in secondary limestone, &c. in the lead mines of Cumberland, Durham, and Westmoreland.

3. *Diprismatic baryte*, or *Strontianite*.—

Colour pale asparagus-green, yellowish-white, and greenish-grey. Massive, in distinct concretions, and crystallized. The primitive form is an oblique four-sided prism, bevelled on the extremities. Secondary figures are, the acicular six-sided prism, and the acicular acute double six-sided pyramid. Lustre glistening or pearly. Cleavage, in the direction of the lateral planes of the primitive form. Fracture fine-grained, uneven. Translucent. Harder than calcareous spar, but softer than fluor. Brittle. Sp. gr. 3·7. Infusible before the blowpipe, but becomes white and opaque, tingeing the flame of a dark purple colour. It is soluble with effervescence in dilute nitric or muriatic acid; and paper dipped in the solutions thus produced burns with a purple flame. Its constituents are,

Strontian,	61·21	69·5	62·0	74·0
Carbonic acid,	30·20	30·0	30·0	25·0
Water,	8.50	0·5	8·0	0·5
	100·0	100·0	100·0	100·0
	Hope.	*Klapr.*	*Pelle.*	*Bucholz.*

It occurs at Strontian in Argyllshire, in veins that traverse gneiss, along with galena, heavy spar, and calcareous spar. "The peculiar earth which characterizes this mineral was discovered by Dr. Hope, and its various properties were made known to the public in his excellent Memoir on Strontites, inserted in the Transactions of the Royal Society of Edinburgh, for the year 1790."—*Jameson*, vol. ii. whose account of the preceding species is a model of mineralogical description.

4. *Axifrangible baryte*, or *Celestine.*—Of this there are five sub-species; foliated, prismatic, fibrous, radiated, and fine granular. We shall describe the foliated, and refer to Professor Jameson's work for the rest.

Colours white, grey, blue, and flesh-red. Massive, in lamellar concretions, and crystallized; in the rectangular four-sided table, in which the terminal planes are bevelled, and in the rectangular four-sided table, bevelled, on the terminal edges. Lustre splendent, pearly. Cleavage threefold. Fracture uneven; fragments rhomboidal. Translucent. Scratches calcareous spar, but is scratched by fluor spar. Sectile, and easily frangible. Sp. gr. 3·9. It melts before the blowpipe into a white friable enamel, without very sensibly tingeing the flame. It is sulphate of strontites, with about 2 per cent. of sulphate of barytes. It occurs in traptuff, in the Calton-hill at Edinburgh, and in red sandstone at Inverness. It is abundant in the neighbourhood of Bristol.—*Jameson.*

HEAT. See CALORIC.

HEDENBERGITE. A mineral of a dark green colour. It occurs massive. Sp. grav. 3.154. It resembles those hornblendes in which iron prevails. It consists of silica 40·62; alumina 0·37; water 16·5 ?; protoxide of iron 35·25; oxide of manganese 0·75; carbonic acid 4·93. *Hedenberg.* Rose has since found it to consist of silica, lime, and protoxide of iron. It is found near Mormorsgrufva, near Tansberg, in Sweden.

HELIOTROPE. A sub-species of rhomboidal quartz. Colour green of various shades. The blood and scarlet-red, and the ochre-yellow dots and spots, are owing to disseminated jasper. Massive, and in angular and rolled pieces. Lustre glistening, resinous. Fracture conchoidal. Translucent on the edges. Easily frangible. Hard, but softer than chalcedony. Rather heavy. Sp. gr. 2·63. It is infusible before the blowpipe. Its constituents are, silica 84, alumina 7·5, and iron 5. It is found in rocks belonging to the secondary trap formation. The finest heliotrope comes from Bucharia and Siberia. A variety is found in the island of Rume in Scotland. It is cut into seals and snuff-boxes. The Siberian wants the red spots.—*Jameson.*

HELIOTROPIUM. TURNSOLE. See ARCHIL.

HELLEBORE. The root of a plant formerly used in medicine, but now nearly discarded from practice, in consequence of the violence of its operation. Vauquelin ascribes its acrimony to a peculiar oil, which he separated from the infusion in alcohol, by distilling off the latter. It is very poisonous. Orfila says, on the contrary, that the poisonous quality of hellebore root resides in a principle soluble in water; that the powdered root is more certainly fatal, when applied to a wound, than when swallowed; that the white hellebore is more active than the black; and that the alkaline extract, which forms a part of the tonic pills of Bacher, is also very powerful. Vomiting is the only antidote.

HELVINE. A sub-species of dodecahedral garnet. Colour wax-yellow. Disseminated, in small granular concretions, and crystallized in small tetrahedrons. Glimmering, or shining. Fracture small-grained, uneven. Crystals strongly translucent. Softer than quartz, but harder than felspar. Brittle. Sp. gr. 3.2 to 3.3. It melts easily into a blackish-brown glass. It occurs along with slate spar, brown blende, and fluor spar, in beds subordinate to gneiss, near Schwartzenberg in Saxony.

HEMATIN. The colouring principle of logwood, the *hematoxylon campechianum* of botanists.

On the watery extract of logwood, digest alcohol for a day, filter the solution, evaporate, add a little water, evaporate gently again, and then leave the liquid at rest. Hematin is deposited in small crystals, which, after washing with alcohol are brilliant, and of a reddish-white colour. Their taste is bitter, acrid, and slightly astringent.

Hematin forms an orange-red solution with boiling water, becoming yellow as it cools, but recovering, with increase of heat, its former hue. Excess of alkali converts it first to purple, then to violet, and lastly, to brown; in which state the hematin seems to be decomposed. Metallic oxides unite with hematin, forming a blue-coloured compound. Gelatin throws down reddish flocculi. Peroxide of tin, and acid, merely redden it.

HEPAR SULPHURIS. A name anciently given to alkaline and earthy sulphurets, from their liver-brown colour.

HEPATIC AIR. Sulphuretted hydrogen gas.

HEPATITE. Fetid, straight, lamellar, heavy spar. A variety of lamellar barytes, containing a minute portion of sulphur; in consequence of which, when it is heated or rubbed, it emits a fetid sulphurous odour.

HERSCHELITE. A mineral in white, translucent, and opaque crystals, found in olivine, brought by Mr. Herschel from Aci Reale in Sicily. It contains silica, alumina, and potash. Sp. gr. 2·11. Fracture conchoidal; easily scratched by the knife. *Annals of Phil.* x. 361.

HETEPOSITE. A mineral sent under this name from the department of the *Haute Vienne;* and which analyzed by M. Vauquelin was found to be a phosphate of iron and manganese. *Ann. de Chim.* xxx. 294.

HEULANDITE. A mineral formerly ranked among the zeolites. It occurs crystallized in a right oblique angled prism, two of its opposite lateral planes being longer than the other two. Externally bright, or pearly. It occurs sometimes massive, frequently in a globular form. Transparent or translucent; colour, white, yellow, or red. Easily frangible. Its constituents are, silica 52·6, alumina 17·5, lime 9, water 18.5. Melts before the blowpipe, with intumescence. It does not form a jelly with acids. It is found in the Faroe Isles, the Hartz, the trap of the Giants' Causeway, and near Paisley. *Phillips' Mineralogy.*

HIGHGATE RESIN. See Fossil Copal.

HISINGERITE. A massive mineral, of a black colour; having a cleavage in one direction, and an earthy fracture in others. Sp. gr. 3·04. Its constituents are oxide of iron 51.5; silica 27·5; alumina 5·5; oxide of manganese 0·77; magnesia, a trace; loss by moisture, 11·75. Before the blowpipe it becomes attractable by the magnet. It is found in the cavities of calcareous spar in Svärta parish in Sudermanland.—*Berzelius.*

HOLLOW SPAR. *Chiastolite.*

HOLMITE. A new mineral, which occurs crystallized in the form of an oblique four-sided prism, and having a sp. gr. of 3.597. Its constituents are 27 lime, 21 carbonic acid, 6½ alumina, 6½ silica, 29 oxide of iron, and 10 water.

HOMBERG'S PHOSPHORUS. Ignited muriate of lime.

HONE. The whet-slate of mineralogists.

HONEY. It is supposed to consist of sugar, mucilage, and an acid.

HONEY-STONE. Mellite. Crystal-Harz of Mohs; the Pyramidal Honey-stone of Jameson. Colour honey-yellow. Rarely massive, but very distinctly crystallized. The primitive form is a pyramid of 118° 4′ and 93° 22′. The following are some of the secondary figures: 1*st*, The primitive pyramid, truncated on the apices, or on the apices and angles; 2*d*, These truncations giving rise to a low rectangular four-sided prism, or to an irregular rhomboidal dodecahedron; 3*d*, The angles in the common base flatly bevelled. Lustre splendent. Cleavage pyramidal. Fracture conchoidal. Semitransparent. Refracts double. Harder than gypsum, but not so hard as calcareous spar. Brittle. Sp. gr. 1·56. Before the blowpipe it becomes white and opaque, with black spots, and is at length reduced to ashes. Heated in a glass tube, it becomes black. Friction makes it slightly resino-electric. Its constituents are 16 alumina, 46 mellitic acid, and 38 water.

It occurs superimposed on bituminous wood and earth coal, and is usually accompanied with sulphur, at Artern in Thuringia. See the sequel of amber, for the criteria between it and mellite.

HOOFS OF ANIMALS. Coagulated albumen, like horn.

HOP. See Lupulin.

HORN. An animal substance, chiefly membranous, composed of coagulated albumen, with a little gelatin, and about half a per cent. of phosphate of lime. But the horns of the buck and hart are of a different nature, being intermediate between bone and horn.

HORN SILVER. Chloride of silver.

HORNBLENDE. A sub-species of straight-edged augite. There are three varieties of hornblende; the common, hornblende-slate, and basaltic hornblende.

1. *Common hornblende.* Colour greenish-black, and black of other shades. Massive, disseminated and crystallized, in a broad, thin, very oblique, four-sided prism, and in a six-sided prism. The lateral planes of the prism are deeply longitudinally streaked. Lustre shining pearly. Cleavage twofold and oblique angular. Fracture uneven. The black hornblende is opaque, the green translucent on the edges. Harder than apatite, but not so hard as felspar. Mountain-green streak. When breathed on, it yields a peculiar smell. Difficultly frangible. Sp. gr. 3·25. It melts before the blowpipe, with violent ebullition, into a greyish-black coloured glass. Its con-

stituents are, 42 silica, 12 alumina, 11 lime, 2·25 magnesia, 30 oxide of iron, 0·25 ferruginous manganese, and 0·75 water, with a trace of potash. It is an essential ingredient of the mountain rocks, syenite, and greenstone, and it occurs frequently in granite, gneiss, &c. It is found abundantly in the British Islands, and on the Continent.

2. *Hornblende-slate.* Colour intermediate between greenish-black, and blackish-green. Massive. Lustre glistening, or pearly. Fracture straight, slaty, Fragments tabular. Opaque. Streak greenish. Semi-hard. Difficultly frangible. It occurs in beds in gneiss, in Aberdeenshire, Banffshire, and Argyllshire, in many parts of England and Ireland, and abundantly on the Continent.

3. *Basaltic hornblende.* Colour velvet-black, or brownish-black. It occurs crystallized, in the following figures: an unequiangular six-sided prism, and the six-sided prism, both variously acuminated. Lustre of the cleavage, which is double, is splendent, approaching to pearly. Fracture small grained, uneven. Opaque. Rather harder than common hornblende, and more easily frangible. Streak dark greyish-white. Sp. gr. 3·16. It fuses into a black glass. Its constituents are, 47 silica, 26 alumina, 8 lime, 2 magnesia, 15 oxide of iron, and 0·5 water. It occurs imbedded in basalt, along with olivine and augite, at Arthur's Seat, near Edinburgh, in Fifeshire, and the Islands of Mull, Canna, Eigg, and Skye. In the basaltic rocks of England, Ireland, and the Continent.—*Jameson.*

HORNSTONE, Professor Jameson's ninth sub-species of rhomboidal quartz. He divides it into splintery hornstone, conchoidal hornstone, and woodstone.

1. *Splintery hornstone.* Colours grey, red, and green. Massive, in balls, lenticular, and in six-sided prismatic supposititious crystals. Dull. Fracture splintery, and somewhat like horn in appearance, whence the name. Translucent on the edges. Less hard than quartz or flint. Difficultly frangible. Sp. gr. 2·6. Infusible before the blowpipe. Its constituents are, 98·25 silica, 0·75 alumina, 0·50 oxide of iron, 0·50 water. It occurs in veins in primitive countries, along with ores of silver, lead, zinc, copper, and iron, and forming the basis of hornstone porphyry. It is found in Arran, Perthshire, Argyllshire, and many other counties of Scotland, and abundantly on the Continent. Hornstone porphyry, at Elfdale in Sweden, is cut into vases, candlesticks, &c. and the pedestal of the statue of Gustavus III. at Stockholm is formed of it.

2. *Conchoidal hornstone.* Colours grey, white, and red. Massive, stalactitic, and rarely in supposititious crystals, whose figures originate from calcareous spar. Lustre glimmering. Fracture conchoidal. Less translucent than the preceding kind, but somewhat harder. Rather difficultly frangible. Sp. gr. 2·58. It occurs in metalliferous veins and agate veins, and along with claystone in the Pentland hills.

3. *Woodstone.* Colours ash-grey and greyish-black. The various shades of colour are in clouded and striped delineations. It occurs in rolled pieces, and in the shape of trunks, branches, and roots. Surface uneven. Dull or glistening. Cross fracture imperfect conchoidal, longitudinal, fibrous. Translucent on the edges. Hard in a low degree. Rather difficultly frangible. Sp. gr. 2·63. It is found imbedded in sandy loam in alluvial soil. It occurs near Lough Neagh, in Ireland; at Chemnitz and Hilbersdorf, in Upper Saxony. It receives a good polish.—*Jameson.*

HORSERADISH ROOT yields, by distillation, an acrid oil, denser than water.

HOSPITAL ULCER, the matter of, consists of a peculiar morbid secretion. It has been successfully treated by washing with dilute nitrate of mercury, nitric acid, and aqueous chlorine.

HUMBOLDITE. This rare mineral occurs in small crystals, nearly colourless and transparent, or with a yellowish tinge; and occasionally opaque. They are usually irregularly aggregated. Shining or splendent. Primary form an oblique rhombic prism. Scratches fluor, but not glass. It seems to contain the same elements as Datolite. It has been found in chalcedonic geodes in trap rocks in the Tyrol.

HUMITE. A mineral of a reddish-brown colour, which occurs crystallized in octohedrons, more or less truncated or bevelled. Planes transversely streaked. Lustre shining. Transparent. Scratches quartz with difficulty. It occurs at Somma near Naples, in a rock composed of grey-coloured granular topaz. It was named by Count Bournon, in honour of Sir Abr. Hume, Bart. a distinguished cultivator of mineralogy.

HURAULITE. A new mineral from the *Haute Vienne* analyzed by M. Vauquelin and found to be composed of

Bases (Iron and Manganese)	47·2
Phosphoric acid . . .	32·8
Water . . .	20·0
	100·0

Ann. de Chim. xxx. 302.

HYACINTH. A sub-species of pyramidal zircon. Colours red, brown, more rarely yellow, green, and grey. It occurs in angular grains, and crystallized in a rectangular four-sided prism, variously acuminated or truncated. Crystals are small. Lustre specular splendent. Cleavage fourfold. Fracture small conchoidal. Semitransparent or transparent, and refracts double. Harder than quartz, but softer than topaz. Rather easily frangible. Sp. gr. 4·6 to 4·78. Before the blowpipe it loses its colour, but not its transparency, and is infusible. Its constituents are,

	from Ceylon,	from Experilty.
Zircon,	70.00	66.00
Silica,	25.00	31.00
Oxide of iron,	0.50	2.00
Loss	4.50	1.00
	100.00	100.00
	Klaproth.	*Vauquelin.*

It occurs embedded in gneiss and syenite, in basalt and lava, and dispersed through alluvial soil; in Auvergne; near Pisa; in the trap rocks round Lisbon; by Professor Jameson in a rolled mass of syenite in the shire of Galloway; and abundantly in Ceylon.

The darker varieties are deprived of their colour by heat, a fact of which artists avail themselves to make zircon resemble diamond. It is esteemed as one of the gems by lapidaries. —*Jameson.*

HYALITE. Colours yellowish and greyish-white. Generally small reniform, botroidal, or stalactitic. Lustre splendent. Fracture small conchoidal. Translucent. Moderately hard. Sp. gr. 2.2. Infusible before the blowpipe. Its constituents are, 92 silica, 6.33 water. It has been hitherto found principally near Frankfort on the Maine, where it occurs in fissures in vesicular basalt and basaltic greenstone. It is cut into ringstones.

HYDRARGYLLITE. *Wavellite.*

HYDRATES. Compounds, in definite proportions, of metallic oxides with water.

HYDRIODATES. Salts consisting of hydriodic acid, combined in definite proportions with oxides.

HYDRIODIC ACID. See ACID (HYDRIODIC), and IODINE.

HYDRIODIDE OF CARBON. See CARBON (CHLORIDE OF).

HYDROCHLORIC ACID. Muriatic acid gas; a compound of chlorine and hydrogen.

HYDROCYANIC ACID. See ACID (PRUSSIC).

HYDROGEN GAS. The lightest species of ponderable matter hitherto known. It was discovered by Mr. Cavendish in 1766. It can be procured only from water, of which it forms an essential constituent.

Into a phial furnished with a bent tube fitted to its cork, or into a retort, put some pieces of pure redistilled zinc, or harpsichord iron wire, and pour on them sulphuric acid diluted with five times its bulk of water. An effervescence will ensue, occasioned by the decomposition of the water, and disengagement of hydrogen, which may be collected in the pneumatic apparatus. For very accurate researches, it must be received in jars over mercury, and exposed to the joint action of dry muriate of lime, and a low temperature. It is thus freed from hygrometric water. In this state its specific gravity is 0.0694 at 60° F. and 30 inches of barom. pressure. 100 cubic inches weigh 2.118 grains. It is therefore about 14.4 times less dense than common air; 16 times less dense than oxygen, and 14 times less dense than azote. In the article *Gas* I have shown, that when it stands over water at 60°, its sp. gr. acquires an increase of nearly one-seventh; and it becomes about 0.77. From the great rarity of hydrogen, it is employed for the purpose of inflating varnished silk bags, which are raised in the air under the name of balloons. See AEROSTATION.

This gas is colourless, and possessed of all the physical properties of air. It has usually a slight garlic odour, arising probably from arsenical particles derived from the zinc. When hydrogen is passed through pure alcohol, the gas loses its odour, and the alcohol then becomes milky with water. When water is transmitted over pure iron in a state of ignition, it yields hydrogen more free from smell. It is eminently combustible, and, if pure, burns with a yellowish-white flame; but, from accidental contamination, its flame has frequently a reddish tinge. If a narrow jar filled with hydrogen be lifted perpendicularly, with the bottom upwards, and a lighted taper be suddenly introduced, the taper will be extinguished, but the gas will burn at the surface, in contact with the air. Animal life is likewise speedily extinguished by the respiration of this gas, though Sir H. Davy has shown, that if the lungs be not previously exhausted by a forced expiration, it may be breathed for a few seconds without much seeming inconvenience. For its point of accension, see COMBUSTION; and for its habitudes with liquids and solids, see GAS.

The discovery by M. Dobereiner that a stream of hydrogen made to play on a few grains of pulverulent or spongy platinum, placed in a little glass cone, ignited it to such a degree as to kindle the gas, may be regarded as one of the most singular phenomena of chemistry. The aperture of the hydrogen jet should be from 1 to 2 inches distant from the platinum, in order that the atmospheric air may be intermingled. The incandescence continues as long as the gas continues to flow. It is truly surprising to see, by a reaction apparently mechanical, between two forms of matter, one the lightest, and the other the densest known, so intense an effect! The compound hydrogenous gases, such as ammonia, olefiant gas, carburetted hydrogen, muriatic acid, &c. are not determined by the platinum powder to appropriate oxygen.

On directing on a mixture of platinum powder, and nitrate of platinum and ammonia, a jet of hydrogen, the mixture ignites with the emission of luminous sparks. The same effect takes place with the black powder of platinum which zinc separates from the solution of this metal, and which is a mixture of protoxide of platinum and platinum powder.

This powder has the power of transforming by degrees, with access of oxygen, alcohol into acetic acid.

Pulverulent platinum is best obtained for this purpose by exposing the precipitated muriate of platinum and ammonia to gentle ignition. When the particles become agglutinated by a higher heat, they are rendered unfit for the experiment. M. Dobereiner had previously shown, in Gilbert's Annals, lxxxii. 193, that not only the protoxide of platinum of Mr. E. Davy, (see PLATINUM), but also the oxidized sulphuret of the same metal, possesses the property of causing alcohol with which it is moistened to be converted, at the expense of the atmospheric oxygen, into vinegar and water. The oxidised sulphuret of Dobereiner is procured by precipitating the solution of this metal with sulphuretted hydrogen, and exposing the washed sulphuret for some weeks to the contact of air. In the singular process of the conversion of alcohol into vinegar and water, 1 atom of alcohol, says he, ($= 46$) absorbs 4 atoms ($= 32$) of oxygen, and forms 1 atom of acetic acid ($= 31$) of acetic acid, and 3 atoms ($= 27$) of water. Equal volumes of oxygen and vapour of alcohol mutually combine to form equal volumes of vapour of acetic acid and vapour of water; for 1 atom of water is requisite for the existence of free acetic acid.

All the combustible gases are absorbed by the above oxide of platinum, and by the oxidized sulphuret of the same metal; but oxygen and carbonic acid are not affected. 160 grains of the oxide absorb from 15 to 20 inches of hydrogen, and develope sufficient heat to ignite the oxide and kindle the hydrogen, if it be previously mixed with oxygen or atmospheric air.

The preparation of platinum, impregnated with hydrogen, greedily attracts the oxygen requisite for converting the hydrogen into water. Hence if the atmospheric air be allowed to penetrate into the tube containing this combination, the air is soon disoxygenated, and if there be less oxygen than is necessary to saturate the hydrogen, the excess of this combines with the azote to form ammonia. The oxide of platinum is reduced in this operation, and no longer possesses the faculty of disposing the alcohol to change into vinegar, nor that of condensing hydrogen, but it is still capable of determining the conversion into water of a mixture of hydrogen and oxygen. Hence he was led to the remarkable action of spongy pulverulent platinum on that gaseous mixture.

M. Dobereiner states, that when the oxidised sulphuret of platinum is put in contact with gaseous oxide of carbon, one half of the volume is condensed, and the remaining gas is carbonic acid. Thus we see that the oxidised sulphuret takes carbon from its oxide.

MM. Dulong and Thenard found, that thin leaf platinum crumpled together into a pellet acted instantly on a mixture of hydrogen and oxygen, though the same leaf rolled round a cylinder of glass, or suspended by itself, did not produce any effect. Palladium, rhodium, with gold and silver, acted, but only at elevated temperatures. Carbonic oxide and oxygen form carbonic acid; nitrous gas is decomposed by hydrogen in contact with spongy platinum; and a mixture of olefiant gas, with sufficient oxygen, is changed into water and carbonic acid.

150 grains of iron wire are sufficient to decompose nearly the whole of a rapid current of ammoniacal gas, transmitted for 8 or 10 hours through a moderately ignited tube; while thrice the weight of platinum wire does not produce the same effect, even at a much higher temperature. Now as iron so well separates the elements of ammonia, and scarcely at all effects the combination of hydrogen with oxygen, while with platinum it is the reverse, these French chemists are induced to suppose, that some gases tend to combine under the influence of metals, and others to separate, the effect varying with the nature of each metal.

Spongy palladium inflames a jet of hydrogen, as well as the platinum; iridium becomes hot, producing water; cobalt and nickel, in masses, cause the gases to combine at about 300° F.; cold spongy platinum forms water and ammonia with nitrous gas and hydrogen; and acted also on mixed hydrogen and nitrous oxide gases.

Mr. Garden, of Oxford Street, found that the black powder, consisting of iridium and osmium, left when crude platinum is digested in nitro-muriatic acid, if heated red hot, and suffered to cool, acts as well as spongy platinum itself. See EUDIOMETER.

When five measures of atmospheric air are mixed with two of hydrogen, and a lighted taper, or an electric spark, applied to the mixture, explosion takes place, three measures of gas disappear, and moisture is deposited on the inside of the glass. When two measures of hydrogen, mixed with one of oxygen, are detonated, the whole is condensed into water. Thus, therefore, we see the origin of the name *hydrogen*, a term derived from the Greek to denote the *water-former*. See WATER. If a bottle containing the effervescing mixture of iron and dilute sulphuric acid be shut with a cork, having a straight tube of narrow bore fixed upright in it, then the hydrogen will issue in a jet, which being kindled, forms the philosophical candle of Dr. Priestley. If a long glass tube be held over the flame, moisture will speedily bedew its sides, and harmonic tones will soon begin to sound. Mr. Faraday, in an ingenious paper inserted in the 10th number of the Journal of Science, states, that carbonic oxide produces, by the action of its flame, similar sounds, and that therefore the effect is not due to the affections of aqueous vapour, as had formerly been supposed. He shows, that the sound is nothing more than the report of a continued explosion, agreeably to Sir H. Davy's just theory of the constitution of flame. Vapour of ether, made to burn from a small aperture, produces the same sonorous effect as the jet of hydrogen, of coal gas, or olefiant gas, on glass and other tubes. Globes from seven to two inches in diameter, with short necks, give very low tones; bottles, Florence flasks and phials, always succeeded; air jars, from four inches diameter to a very small size, may be used. Some angular tubes were constructed of long narrow slips of glass and wood, placing three or four together, so as to form a triangular or square tube, tying them round with pack-thread. These held over the hydrogen jet gave distinct tones.

Hydrogen, combined with

Oxygen,	forms water.
Chlorine,	muriatic acid.
Iodine,	hydriodic acid.
Cyanogen,	prussic acid.
Carbon,	subcarb. and carb. hydr.
Azote,	ammonia.
Phosphorus,	subphos. and phos. hydr.
Sulphur,	sulph. and subsul. hydr.
Arsenic,	arsenuretted hydrogen.
Tellurium,	telluretted hydrogen.
Potassium,	potassuretted hydrogen.

For an account of these several compounds, see the respective bases. From the proportion in which it combines with these bodies, its prime equivalent on the oxygen radix is fixed at 0.125. It is the body which gives the power of burning with flame to all the substances used for the economical production of heat and light.

In that valuable repository of philosophical facts, Tilloch's Magazine, we have the following notice of the effect of hydrogen gas on the voice: "The *Journal Britannique*, published at Geneva by Prevost, contains the following article: 'Maunoir was one day amusing himself with Paul at Geneva, in breathing pure hydrogen air. He inspired it with ease, and did not perceive that it had any sensible effect on him, either in entering his lungs, or passing out. But after he had taken in a very large dose, he was desirous of speaking, and was astonishingly surprised at the sound of his voice, which was become soft, shrill, and even squeaking, so as to alarm him. Paul made the same experiment on himself, and the same effect was produced. I do not know whether any thing similar has occurred in breathing any of the other gases.'" Vol. iv. p. 214.

HYDROGURET of sulphur. See SULPHUR.

HYDROMETER. The best method of weighing equal quantities of corrosive volatile fluids, to determine their specific gravities, appears to consist in enclosing them in a bottle with a conical stopper, in the side of which stopper a fine mark is cut with a file. The fluid being poured into the bottle, it is easy to put in the stopper, because the redundant fluid escapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as possible, by avoiding any contact of the bottle with the hand, or otherwise. The bottle itself shows with much precision, by a rise or fall of the liquid in the notch of the stopper, whether any such change have taken place. See SPECIFIC GRAVITY and ALCOHOL.

The hydrometer of Fahrenheit consists of a hollow ball, with a counterpoise below, and a very slender stem above, terminating in a small dish. The middle, or half length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is immersed in all experiments to the middle of the stem, by placing proper weights in the little dish above. Then, as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known, this last weight added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, as all writers on hydrostatics prove. And accordingly, the sp. gravities for the common form of the tables will be had by the proportion:

As the whole weight of the hydrometer and its load, when adjusted in distilled water,
Is to the number 1000, &c.
So is the whole weight when adjusted in any other fluid
To the number expressing its specific gravity.

The hydrometers, or *pese-liqueurs*, of Beaumé, though in reality comparable with each other, are subject in part to the defect, that their results, having no independent numerical measure, require explanation to those who do not know the instruments.

Beaumé's Hydrometer for Spirits.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
10 =	1·000	17 =	·949	23 =	·909	29 =	·874	35 =	·842
11	·990	18	·942	24	·903	30	·868	36	·837
12	·985	19	·935	25	·897	31	·862	37	·832
13	·977	20	·928	26	·892	32	·857	38	·827
14	·970	21	·922	27	·886	33	·852	39	·822
15	·963	22	·915	28	·880	34	·847	40	·817
16	·955								

With regard to the hydrometer for salts, the learned author of the first part of the Encyclopædia, Guyton de Morveau, who by no means considers this an accurate instrument, affirms, that the sixty-sixth degree corresponds nearly with a specific gravity of 1·848; and as this number lies near the extreme of the scale, I shall use it to deduce the rest.

Beaumé's Hydrometer for Salts.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
0 =	1·000	15 =	1·114	30 =	1·261	45 =	1·455	60 =	1·717
3	1·020	18	1·140	33	1·295	48	1·500	63	1·779
6	1·040	21	1·170	36	1·333	51	1·547	66	1·848
9	1·064	24	1·200	39	1·373	54	1·594	69	1·920
12	1·089	27	1·230	42	1·414	57	1·659	72	2·000

It may not be amiss to add, however, that in the Philosophical Magazine, Mr. Bingley, the assay master of the mint, has given the following numbers as the specific gravity of nitric acid, found to answer to the degrees of an areometer of Beaumé by actual trial; temperature about 60° Fahr. But his appears to have been a different instrument, as it was graduated only from 0 to 50°.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
18 =	1·150	29 =	1·250	34 =	1·300	38 =	1·350	42	1·400
20	1·167	30	1·267	35	1·312	39	1·358	43	1·416
26	1·216	31	1·275	36	1·333	40	1·367	45	1·435
28	1·233	32	1·283	37	1·342	41	1·383		

There are a variety of hydrometers used for determining the strength of ardent spirit. See Alcohol and Distillation.

HYDROPHANE. A variety of opal, which has the property of becoming transparent on immersion in water. It is also called *oculus mundi.* We must be careful to immerse them only in pure water, and to withdraw them whenever they have acquired their full transparency. If we neglect these precautions, the pores will soon become filled with earthy particles deposited from the water, and the hydrophane will cease to exhibit this curious property, and will remain always more or less opaque.

HYDROSULPHURETS. Compounds of sulphuretted hydrogen with the salifiable bases.

HYDROTHIONIC ACID. Sulphuretted hydrogen, the hydrosulphuric acid of M. Gay Lussac.

HYDRURETS. Compounds of hydrogen with metals.

HYOSCIAMA. A new vegetable alkali, extracted by Dr. Brandes from the hyosciamus nigra, or henbane. It crystallizes in long prisms, and when neutralized by sulphuric acid, or nitric acid, forms characteristic salts.—The examination of the alkaline constituents of narcotic plants demands great circumspection, because in them the whole poisonous properties of the plant are concentrated. The vapour is particularly prejudicial to the eyes. The smallest morsel put upon the tongue is very dangerous.

HYPEROXYMURIATES. Salts now called Chlorates. See Acid (Chloric) in the sequel of Acid (Muriatic).

HYPONITROUS ACID. See Acid (Nitrous).

HYPERSTENE. Labradore schillerspar.

Colour between greyish and greenish-black, but nearly copper-red on the cleavage. Massive, disseminated, and in thin, curved, lamellar concretions. Lustre shining, metallic pearly. Cleavage double oblique angular. Opaque. Streak greenish-grey. Hard as felspar. Brittle. Sp. gr. 3.4. Infusible before the blowpipe. Its constituents are, 54·25 silica, 14 magnesia, 2·25 alumina, 1·50 lime, 24·5 oxide of iron, 1 water, and a trace of manganese. It has been found in Labradore, Greenland, and by Dr. M'Culloch in the Isle of Skye. It has a beautiful copper-red colour when cut and polished into ring-stones or brooches.

HYPOPHOSPHOROUS ACID. See Acid (Hypophosphorous).

HYPOSULPHUROUS ACID. See Acid (Hyposulphurous).

HYPOSULPHURIC ACID. See Acid (Hyposulphuric); which three acids are treated of under the phosphoric and sulphuric.

I & J

JADE. See Nephrite.

JALAP. A root used in medicine as a purgative. By M. Henry's analysis, the constituents of three different varieties of this root are,

	Jal. leger.	Jal. sain.	Jal. pique.
Resin,	60	48	72
Extract,	75	140	125
Starch,	95	102	103
Woody fibre,	270	210	200
	500	500	500

JALAPIN. Mr. Hume, jun., of Long Acre, procures a substance which he has so named, in the following manner. Coarsely powdered jalap is macerated for 12 or 14 days in strong acetic acid; and the coloured solution being filtered, is to be treated with ammonia in excess, and the mixture is to be violently shaken. A sandy-looking deposite rapidly falls, and a few crystals form on the sides of the vessel. Both of these are to be washed with distilled water, re-dissolved in acetic acid, reprecipitated by ammonia, whence jalapine falls down in small white acicular crystals.

It has neither taste, nor smell; is scarcely soluble in cold water, and slightly so in hot. It is insoluble in ether; but dissolves abundantly in alcohol. Mr. Hume supposes that an ounce of jalap will afford 5 grains of this substance. *Med. Journ.* li. 346.

JARGON. See Zircon.

JASPER. A sub-species of the rhomboidal quartz of Professor Jameson. He enumerates five kinds: Egyptian jasper, striped, porcelain, common, and agate jasper.

1. *Egyptian jasper*, of which there is red and brown. The first is flesh-red, blood-red, yellow, and brown, in ring-shaped delineations. In roundish pieces. Dull. Fracture conchoidal. Feebly translucent on the edges. Hard. Easily frangible. Sp. gr. 2·63. It is found imbedded in red clay-ironstone at Baden, and is cut into ornaments.

The *brown* has its various shades of colour disposed in concentric stripes, alternating with black stripes. In spheroidal masses. Lustre glimmering. Fracture conchoidal. Feebly translucent on the edges. As hard as hornstone. Sp. gr. 2·6. It is infusible. It occurs loose in the sands of Egypt. It is cut into ornaments.

2. *Striped jasper*. Colours grey, green, yellow, red, arranged in stripes, in flamed, or spotted delineations. Massive in whole beds. Dull. Fracture conchoidal. Opaque. Less hard than Egyptian jasper. Rather easily frangible. Sp. gr. 2.5. It occurs in secondary clay-porphyry in the Pentland-hills, and near Friburg in Saxony. It receives a fine polish.

3. *Porcelain jasper*. Colours grey, blue, yellow, generally of one colour, or with clouded delineations. Massive, and cracked in all directions. Lustre glistening. Fracture conchoidal. Opaque. Easily frangible, and not very hard. Sp. gr. 2·5. Fuses into a white or grey glass. Its constituents are 60·75 silica, 27·25 alumina, 3 magnesia, 2·5 oxide of iron, and 3·66 potash. It is always found along with burnt clay and earth slags. According to Werner, it is slate-clay converted into a kind of porcelain, by the heat of a pseudo-volcano, from beds of burning coal. It is found on the coast of Fifeshire, in Shropshire, and Warwickshire, and some parts of Germany, where immense beds of coal appear.

4. *Common jasper*. Colours red and brown. Massive. Lustre, from shining to dull. Fracture conchoidal. Opaque. Hard in a low degree. Rather easily frangible. Sp. gr. 2·6. Infusible before the blowpipe, becoming at last white. It occurs principally in veins as a constituent of agate. It is found in the Pentland-hills, and in trap and transition rocks in Ayrshire and Dumfries-shire. It receives a good polish.

5. *Agate jasper*. Colours yellowish-white and reddish-white. Massive. Dull. Fracture flat conchoidal. Opaque. Hard in a low degree. It occurs in layers in agate balls, in many places.

ICE. See Caloric, Temperature, Thermometer, Water.

ICELAND SPAR. See Calcareous Spar.

ICE-SPAR. A sub-species of felspar.

ICHTHYOPHTHALMITE. See Apophyllite.

ICHTHYOCOLLA. Fish glue, or *Isinglass*.

IDOCRASE. See Vesuvian.

JEFFERSONITE. A new mineral, found in lamellar masses, imbedded in Franklinite and garnet. Hardness between fluor spar and apatite. Sp. gr. 3·53. Colour dark olive-green, passing into brown. Slightly translucent on the edges. Lustre slight. Greyish streak. Melts readily before the blowpipe. It presents three distinct cleavages. Constituents: silica 56, lime 15·1, protox. manganese 13·5, perox. iron 10, oxide of zinc 1·0, alumina 2·0; loss by calcination 1·0. Loss 1·4 in 100.—*Mr. Keating in Annals of Phil.* N. S. iv. 234.

JELLY, of ripe currants and other berries; a compound of mucilage and acid, which loses its gelatinizing power by long boiling.

JENITE. See LIEVRITE.

JET. See PITCH COAL.

IGASURIC ACID. See ACID (IGASURIC).

IGNIS FATUUS. A luminous appearance or flame, frequently seen in the night in different country places, and called in England *Jack with a lantern*, or *Will with the wisp*. It seems to be mostly occasioned by the extrication of phosphorus from rotting leaves and other vegetable matters. It is probable that the motionless ignes fatui of Italy, which are seen nightly on the same spot, are produced by the slow combustion of sulphur, emitted through clefts and apertures in the soil of that volcanic country.

INCINERATION. The combustion of vegetable or animal substances, for the purpose of obtaining their ashes or fixed residue.

INCOMBUSTIBLE CLOTH. See ASBESTUS.

INDIANITE. A mineral of a whitish or greyish colour, with a shining lustre; translucent; scratches glass, but is scratched by felspar. Sp. grav. about 2·74. It consists of, silica 42·5; alumina 37·5; lime 15; iron 3; and a trace of manganese. It is the gangue of Corundum from the Carnatic.

INDICOLITE. A variety of tourmaline of an indigo-blue colour, found in the mine of Utoe in Sweden, in crystals. Klaproth found it to contain, alumina 40; silica 35; oxide of iron 22.

INDIGO. A blue colouring matter extracted from a plant called Anil, or the Indigo Plant.

In the preparation of this drug, the herb is put into a vat or cistern called the steeping trough, and there covered with water. The matter begins to ferment sooner or later, according to the warmth of the weather and the maturity of the plant; sometimes in six or eight hours, and sometimes in not less than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue colour inclining to violet. At this time, without touching the herb, the liquor impregnated with its tincture is let out by cocks in the bottom into another vat placed for that purpose so as to be commanded by the first.

In the second vat, called the beating vat, the liquor is strongly and incessantly beaten with a kind of buckets fastened to poles, till the colouring matter is united into a body.

As soon as it is judged, from the blue colour of the liquid, that the beating is sufficient, it is left at rest for two hours; after which the clear liquor is drawn off by cocks in the side of the vat, and the blue part is discharged by another cock into a third vat, where it is suffered to settle for some time longer; then conveyed in a half fluid state into bags of cloth, to strain off more of its moisture; and, lastly, exposed to the air in the shade in shallow wooden boxes, till it is thoroughly dry.

Indigo does not change in the air. It is insoluble in water and ether, but perceptibly soluble in boiling alcohol, which it dyes blue, and from which it falls down in a great measure on cooling. It is instantly decomposed by chlorine. When one part of finely triturated indigo is mixed with 9 or 10 parts of concentrated sulphuric acid, a solution takes place, and in a few hours if the temperature be about 100° F. The indigo is possibly slightly altered in this process; for though its colour is unchanged, it has acquired the property of dissolving in several menstrua which formerly had no action on it, and it is no longer susceptible of vaporization.

Concentrated nitric acid exercises a very powerful action on indigo. Even when diluted, its action is still considerable, and several products are formed; viz. besides those derived from most vegetable substances, ammonia, a resinous matter, and bitter principle. When 14 parts of nitric acid, sp. gr. 1·430, and 1 part of Guatimala indigo are distilled together, about a fourth part of a peculiar acid is obtained with a small quantity of yellow bitter substance. Repeated washing in alcohol and distilled water separated this substance, and the acid being dissolved in boiling water, and crystallized by cooling, was obtained pure. The acid is always of a yellow colour, of a bitter taste, crystalline, soluble in water, and when placed upon a hot coal deflagrates somewhat like nitre. Combined with potash, soda, ammonia, barytes, and lime, it forms neutral salts, the whole of which are fulminating. It is quite different from benzoic acid, which was said by Berthollet, Fourcroy, and Vauquelin, to be formed from nitric acid and indigo.—*Giornale di Fisica*, vii. 414.

Neither liquid muriatic acid nor alkaline solutions exert any considerable action on indigo.

Bergmann concludes, from his analysis, that 100 parts of good indigo contain of mucilaginous matter separable by water 12, resinous matter soluble in alcohol 6, earthy matter taken up by the acetic acid, which does not attack the iron, here, in the state of oxide, 22, oxide of iron taken up by the muriatic acid 13.

There remained 47 parts, which are the colouring matter, nearly in a state of purity.

M. Chevreul has given the following results of a very elaborate analysis of Guatimala indigo.

By water	Ammonia,	12
	Disoxygenized indigo,	
	Green matter,	
	Bitter matter,	
By alcohol	Green matter,	30
	Red matter,	
	Indigo,	
By muriatic acid	Red matter,	6
	Carbonate of lime,	2
	Oxide of iron and alumina,	2
	Silica,	3
	Pure indigo,	45
		100

When commercial indigo is exposed to a heat of about 400° F. it evolves a beautiful crimson smoke, which may be condensed in crystalline needles, which are pure indigo. The blue vat of the dyer contains indigo deoxidized by protoxide of iron, and rendered soluble in its yellow-green state by lime water. If a portion of this solution be exposed to the air, in a shallow vessel, the indigo will speedily absorb oxygen, and precipitate in its usual state of an insoluble blue powder. This being dried, and digested in a mixture of alcohol and muriatic acid, becomes also pure indigo by the abstraction of all the resin and lime. In this state it is a soft powder, of an intensely deep blue, verging sometimes on purple. It is unchangeable by the air. Every substance which has a great affinity for oxygen, when digested with indigo, deprives it of the blue colour, and converts it, either permanently or for a time, to a yellow or greenish-yellow hue. Thus, if into the sulphate of indigo above described are put a few pieces of iron or zinc, the nascent hydrogen seizes its oxygen, and discolours it. Sulphuretted hydrogen acts on indigo at common temperatures; and there results, besides indigo at the *minimum* of oxidation, water, and probably a slight deposite of sulphur. The experiment should be made in a close vessel, and it takes two or three days for its completion. Hydrosulphuret of ammonia has the same effect. Indigo may be also deoxidized in the cold, by the solution of protoxide of tin in potash, a solution procurable (according to M. Thenard) by pouring liquor of potash in excess on the protomuriate. The protoxide passes to the state of deutoxide, and the potash combines with the disoxygenized indigo. When indigo is deoxidized by orpiment, it is better to promote the action by heat. The proportions to be employed are, 8 parts of orpiment, 6 of alkali, 8 of indigo, and 100 of water. Sulphite and arsenite of potash are undoubtedly formed, while the deoxidized indigo combines with a portion of alkali, as in the other cases of solution.

Mr. Crum, in his elaborate paper on indigo (Annals of Philosophy for Feb. 1823), says that the long flat needles of sublimed indigo split readily, when bruised, into four-sided prisms. Viewed at a particular angle, they have the most brilliant and intense copper colour; but when lying in heaps, they have a rich chestnut brown colour. The sp. gr. of sublimed indigo is 1·35. By my analysis, indigo consists in 100 parts of 71·37 charcoal, 4·38 hydrogen, 14·25 oxygen, 10 azote. By Mr. Crum's, its constituents are, carbon 73·22, hydrogen 2·92, oxygen 12·60, and azote 11·26 in 100 parts. The indigo, when modified by solution in sulphuric acid, he calls *cerulin*. When it undergoes a further modification by the same acid, he names it *phenicin*.

Sulphuric acid, rendered smoking by a little sulphurous acid, is a better solvent of indigo than pure oil of vitriol. By boiling a little sulphur in this, its solvent power is improved. Nitric acid, digested on indigo, is said to convert it into Mr. Hatchett's artificial tannin, a bitter principle, with oxalic and benzoic acids. See above.

When indigo is mixed with liquid fermentable materials, it is speedily deoxydized.

INK. Every liquor or pigment used for writing or printing, is distinguished by the name of ink. Common practice knows only black and red.

Of black ink there are three principal kinds: 1. Indian Ink; 2. Printers' ink; and, 3. Writing ink.

The Indian ink is used in China for writing with a brush and for painting upon the soft flexible paper of Chinese manufacture. It is ascertained, as well from experiment as from information, that the cakes of this ink are made of lampblack and size, or animal glue, with the addition of perfumes or other substances not essential to its quality as an ink. The fine soot from the flame of a lamp or candle received by holding a plate over it, mixed with clean size from shreds of parchment or glove-leather not dyed, will make an ink equal to that imported.

Good printers' ink is a black paint, smooth, and uniform in its composition, of a firm black colour, and possesses a singular aptitude to adhere to paper thoroughly impregnated with moisture.

The consistence and tenacity of the oil in this composition are greatly increased, and its greasiness diminished, by means of fire. Linseed oil or nut oil is made choice of for this use. The nut oil is supposed to be the best, and is accordingly preferred for the black ink, though the darker colour it acquires from the fire renders it less fit for the red. It is said that the other expressed oils cannot be sufficiently freed from their unctuous quality.

Ten or twelve gallons of the oil are set over the fire in an iron pot, capable of holding at least half as much more; for the oil swells up greatly, and its boiling over into the fire would be very dangerous. When it boils it is kept stirring with an iron ladle; and if it do not itself take fire, it is kindled with a piece of flaming paper or wood; for simple boiling, without the actual accension of the oil, does not communicate a sufficient degree of the drying quality required. The oil is suffered to burn for half an hour or more, and the flame being then extinguished by covering the vessel close, the boiling is afterwards continued with a gentle heat, till the oil appears of a proper consistence; in which state it is called varnish. It is necessary to have two kinds of this varnish, a thicker and a thinner, from the greater or less boiling, to be occasionally mixed together, as different purposes may require: that which answers well in hot weather being too thick in cold, and large characters not requiring so stiff an ink as small ones.

The thickest varnish, when cold, may be drawn into threads like weak glue; by which criterion the workmen judge of the due boiling, small quantities being from time to time taken out and dropped upon a tile for this purpose. It is very viscid and tenacious, like the soft resinous juices, or thick turpentine. Neither water nor alcohol dissolves it; but it readily enough mingles with fresh oil, and unites with mucilages into a mass diffusible in water in an emulsive form. Boiling with caustic alkali produces a soapy compound. It is by washing with hot soap-leys and a brush that the printers clean their types. The oil loses from one-tenth to one-eighth of its weight by the boiling into the thick varnish.

It is affirmed, that varnish containing either turpentine or litharge, particularly the latter, is more adhesive than other varnish, and presents a great difficulty in cleaning the types, which soon become clogged. Very old oil requires neither of these additions. New oil can hardly be brought into a proper state for drying, so as not to set off, without the use of turpentine.

Lampblack is the common material to give the black colour, of which two ounces and a half are sufficient for sixteen ounces of the varnish. Vermilion is a good red. They are ground together on a stone with a muller, in the same manner as oil paints.

The ink used by copperplate printers differs in the oil, which is not so much boiled as to acquire the adhesive quality. This would render it less disposed to enter the cavities of the engraving, and more difficult either to be spread or wiped off. The black is likewise of a different kind. Instead of lampblack, or sublimed charcoal, the Frankfort black is used, which is a residual or denser charcoal, said to be made from vine-twigs. This is softer and less gritty than the ivory or other blacks prepared among us, and, no doubt, contains more coal than any animal residue, as all these abound with phosphate of lime. It is said, that lampblack gives always a degree of toughness to the ink, which the Frankfort black does not; but the goodness of the colour seems to be the leading inducement for the use of the latter. A pale or brown-black can be much more easily endured in a book, than in the impression of an engraving.

We have no good explanation of what happens with regard to the chemical effect of boiling and burning upon the oil for printers' use.

Common ink for writing is made by adding an infusion or decoction of the nut-gall to sulphate of iron, dissolved in water. A very fine black precipitate is thrown down, the speedy subsidence of which is prevented by the addition of a proper quantity of gum-arabic. This is usually accounted for by the superior affinity of the gallic acid, which, combining with the iron, takes it from the sulphuric, and falls down. But it appears as if this were not the simple state of the facts; for the sulphuric acid in ink is not so far disengaged as to act speedily upon fresh iron, or give other manifestations of its presence in an uncombined state. According to Deyeux, the iron in ink is partly in the state of a gallate.

M. Ribaucourt paid particular attention to the process for making black ink, and from his experiments he draws the following inferences:—That logwood is a useful ingredient in ink, because its colouring matter is disposed to unite with the oxide of iron, and renders it not only of a very dark colour, but less capable of change from the action of acids, or of the air. Sulphate of copper, in a certain proportion, gives depth and firmness to the colour of the ink. Gum-arabic, or any other pure gum, is of service, by retarding the precipitation of the feculæ; by preventing the ink from spreading or sinking into the paper; and by affording it a kind of compact varnish, or defence from the air when dry. Sugar appears to have some bad qualities, but is of use in giving a degree of fluidity to the ink, which permits the dose of gum to be enlarged beyond what the ink would bear without it. Water is the best solvent.

Lewis had supposed, that the defects of ink arise chiefly from a want of colouring matter. But the theory grounded on the fact discovered by M. Ribaucourt requires, that none of the principles should be in excess.

It is doubtful whether the principles of the galls be well extracted by maceration; and it is certain, that inks made in this way flow pale from the pen, and are not of so deep a black as those wherein strong boiling is recurred to.

From all the foregoing considerations M. R. gives these directions for the composition of good ink:—

Take eight ounces of Aleppo galls (in coarse powder); four ounces of logwood (in thin chips); four ounces of sulphate of iron; three ounces of gum-arabic (in powder); one ounce of sulphate of copper; and one ounce of sugar-candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has evaporated. Strain the decoction through a hair sieve or linen cloth, and then add the other ingredients.

Stir the mixture till the whole is dissolved, more especially the gum; after which, leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone-ware, well corked.

Many recommend, that the sulphate of iron should be calcined to whiteness. Mr. Desormeaux, jun. an ink manufacturer in Spitalfields, has given the following in the Philosophical Magazine, as the result of much experience:—Boil four ounces of logwood about an hour in six beer quarts of water, adding boiling water from time to time; strain while hot; and when cold, add water enough to make the liquor five quarts. Into this put one pound avoirdupois of blue galls coarsely bruised; four ounces of sulphate of iron calcined to whiteness; three ounces of coarse brown sugar; six ounces of gum-arabic; and ¼ ounce of acetate of copper, triturated with a little of the decoction to a paste, and then thoroughly mixed with the rest. This is to be kept in a bottle uncorked about a fortnight, shaking it twice a-day, after which it may be poured from the dregs, and corked up for use.

Dr. Lewis uses vinegar for his menstruum; and M. Ribaucourt has sulphate of copper among his ingredients. I have found an inconvenience from the use of either, which, though it does not relate to the goodness of the ink, is sufficiently great, in their practical exhibition, to forbid their use. The acid of the vinegar acts so strongly upon the pen, that it very frequently requires mending; and the sulphate of copper has a still more unpleasant effect on the penknife. It seldom happens when a pen requires mending, that the ink is wiped very perfectly from it; and often, when the nib only is to be taken off, it is done without wiping at all. Whenever this is the case, the ink immediately deposits a film of copper upon the knife, and by superior elective attraction of the sulphuric acid, a correspondent portion of the edge of the knife is dissolved, and is by this means rendered incapable of cutting till it has been again set upon the hone.

If a little sugar be added to ink, a copy of the writing may easily be taken off, by laying a sheet of thin unsized paper, damped with a sponge, on the written paper, and passing lightly over it a flat iron very moderately heated.

Inks of other colours may be made from a strong decoction of the ingredients used in dyeing, mixed with a little alum and gum-arabic. For example, a strong decoction of Brazil wood, with as much alum as it can dissolve, and a little gum, forms a good red ink. These processes consist in forming a lake, and retarding its precipitation by the gum. See Lake.

On many occasions it is of importance to employ an ink indestructible by any process, that will not equally destroy the material on which it is applied. Mr. Close has recommended for this purpose twenty-five grains of copal in powder dissolved in 200 grains of oil of lavender, by the assistance of gentle heat, and then mixed with two and a half grains of lampblack, and half a grain of indigo; or 120 grains of oil of lavender, seventeen grains of copal, and sixty grains of vermilion. A little oil of lavender, or of turpentine, may be added, if the ink be found too thick. Mr. Sheldrake suggests, that a mixture of genuine asphaltum dissolved in oil of turpentine, amber varnish, and lampblack, would be still superior.

When writing with common ink has been effaced by means of aqueous chlorine, the vapour of sulphuret of ammonia, or immersion in water impregnated with this sulphuret, will render it again legible. Or, if the paper that contained the writing be put into a weak solution of prussiate of potash, and when it is thoroughly wet, a little sulphuric acid be added to the liquor, so as to render it slightly acidulous, the same purpose will be answered.

Mr. Haussman has given some compositions for marking pieces of cotton or linen, previous to their being bleached, which are capable of resisting every operation in the processes both of bleaching and dyeing, and, consequently, might be employed in marking linen for domestic purposes. One of these consists of asphaltum dissolved in about four parts of oil of turpentine, and with this is to be mixed lampblack, or black lead in fine powder, so as to make an ink of a proper consistence for printing with types. Another, the blackish sulphate left after expelling oxygen gas from oxide of manganese with a moderate heat, being dissolved and filtered, the dark grey pasty oxide left on the filter is to be mixed with a very little solution of gum-tragacanth, and the cloth marked with this is to be dipped in a solution of potash or soda, mild or caustic, in about ten parts of water.

Among the amusing experiments of the art of chemistry, the exhibition of sympathetic inks holds a distinguished place. With these the writing is invisible, until some reagent gives it opacity. We shall here mention a few out of the great number, that a slight acquaintance with chemistry may suggest to the student. 1. If a weak infusion of galls be used, the writing will be invisible till the paper be moistened with a weak solution of sulphate of iron. It then becomes black, because these ingredients form ink. 2. If paper be soaked in a weak infusion of galls, and dried, a pen dipped in the solution of sulphate of iron will write black on that paper, but colourless on any other paper. 3. The diluted solutions of gold and silver remain colourless upon the paper, till exposed to the sun's light, which gives a dark colour to the oxides, and renders them visible. 4. Most of the acids, or saline solutions, being diluted, and used to write with, become visible by heating before the fire, which concentrates them, and assists their action on the paper. 5. Diluted prussiate of potash affords blue letters when wetted with the solution of sulphate of iron. 6. The solution of cobalt in aqua regia, when diluted, affords an ink which becomes green when held to the fire, but disappears again when suffered to cool. This has been used in fanciful drawings of trees, the green leaves of which appear when warm, and vanish again by cold. If the heat be continued too long after the letters appear, it renders them permanent. 7. If oxide of cobalt be dissolved in acetic acid, and a little nitre added, the solution will exhibit a pale rose colour when heated, which disappears on cooling. 8. A solution of equal parts of sulphate of copper and muriate of ammonia, gives a yellow colour when heated, that disappears when cold.

Sympathetic inks have been proposed as the instruments of secret correspondence. But they are of little use in this respect, because the properties change by a few days remaining on the paper; most of them have more or less of a tinge when thoroughly dry; and none of them resist the test of heating the paper till it begins to be scorched.

Nitrate of silver for a surface impregnated with carbonate of soda, and muriate of gold for one impregnated with protomuriate of tin, form good indelible inks.

INSECTS. Various important products are obtained from insects. The chief are, 1. Cantharides; 2. Millepedes; 3. Cochineal; 4. Kermes; 5. Lac; 6. Silk; 7. Wax.

INSTRUMENTS (CHEMICAL). See Balance, Thermometer, Laboratory.

INTESTINAL CONCRETIONS. For a description of such of these as occur in the inferior animals, see Bezoar.

I shall here insert an account of a very curious concretion extracted from the rectum of a woman in Perthshire, in the year 1817. She is, I believe, still alive. It was sent to me by her physician, Dr. Kennedy of Dunning. The following paper was written at the time, and an abstract published in a London Medical Journal, in the autumn of the same year.

The form of the concretion is a compressed cylinder; the length and larger diameter, each one inch; the smaller diameter, three quarters of an inch. In hardness it is equal to wax, but without its tenacity. One of the ends, which is polished and glistening, exhibits the appearance of concentric laminæ, formed of circular brown lines, in a yellow basis. Its sides have the lustre and marbled appearance of Castile soap. Its internal structure is granular, approaching to crystalline, with radiations from the centre to the circumference, of brown and bright yellow lines, possessed of pearly lustre. It is friable between the fingers, covering them, on pressure, with a mealy powder, of but little unctuosity.

Its weight is 167.5 grains. Specific gravity of the mass seems at first inferior to that of distilled water; for it floats on it for a little, but it afterwards sinks to the bottom. In a solution of muriate of soda, sp. gr. 1.0135, a fragment of it remains suspended in any part of the fluid. This, therefore, is its specific gravity.

Its odour is strong, but by no means disagreeable. It is decidedly musky, or more precisely that of ambergris.

Water has no action on it, nor does it affect the purple of litmus. It remains solid in boiling water. When it is heated to the temperature of about 400° F., it fuses into a black mass, and exhales a copious white smoke, in the odour of which we may recognize that of ambergris, mixed with the smell of burning fat. Exposed in a platina capsule to a dull red heat, it burns with much flame and smoke, leaving no appreciable residuum.

It dissolves rapidly in sulph. ether, forming an amber-coloured liquid. When the ether evaporates away, white glistening scales, of a micaceous appearance, are left.

Ten parts of hot alcohol dissolve one of it, but as the alcohol cools, the greater part precipitates in these soft crystalline scales, while the surface of the liquid becomes covered with a beautiful iridescent pellicle, presenting stellated radiations.

Naphtha, the fixed and volatile oils, readily act upon it, forming bright yellow solutions.

Small fragments of it, exposed on a sand bath, for two days, in a glass capsule, containing the water of pure potash, were not found to be altered in their size or appearance. Neither does liquid ammonia, digested on it, produce the slightest effect. In these respects, it possesses more analogies with ambergris than with any other substance I know. I was hence led to imagine that the white smoke which it exhales at a moderate heat was benzoic acid, which this substance is said copiously to contain.

An alcoholic solution of the concretion was therefore added to water of ammonia, when a milky liquid was produced by the separation of the substance, in a finely divided state. This mixture was evaporated to dryness by a gentle heat, in order to get rid of the alcohol and uncombined ammonia. Warm water was then digested on the residuum, and the whole poured on a filter. The liquid which passed through should have contained benzoate of ammonia, provided any benzoic acid existed in the concretion. It was divided into two portions. Into one of these a few drops of dilute sulphuric acid were poured, and the acidulous fluid was then concentrated by evaporation in a glass capsule; but on cooling, it afforded no traces of benzoic acid. An extremely minute quantity of benzoate of ammonia, treated in the same way, for comparison, gave the characteristic crystals of that acid. The other portion was added to a neutral solution of red muriate of iron, but no precipitate ensued. A very small particle of crystallized benzoate of ammonia being added to the same muriate, speedily gave the brown precipitate, but produced no change whatever on solutions, perfectly neutral, of the *green* muriate and sulphate; a fact of consequence to show the state of oxidisement, in which iron exists in a mineral or saline combination, indicating also an easy method of separating the two oxides of this metal. From the above experiments we may infer, with much probability, that the concretion contains no benzoic acid.

Nitric acid, sp. gravity 1.300, digested on it at a gentle heat, and then cooled, converted the substance into bright yellow globules, denser and less friable than the original matter, and somewhat semitransparent, like impure rosin. There was, however, no true solution by the acid; nor was the combustibility in the least impaired, by the operation.

As our Institution possesses specimens of very fragrant ambergris, said to have been imported in the genuine state from Persia, I was desirous to compare their chemical relations with those of this morbid concretion. Two of the pieces of ambergris differ in many respects from one another. The first is of a light grey colour, with resinous looking points interspersed through it, and has a density considerably greater than water. It is 1.200. When heated in water to the temperature of 130°, it falls down into light spongy fragments. The second has a specific gravity of 0.959; it is darkish brown on the outside, and light brown within. In water heated to the above degree, it softens into a viscid substance like treacle. Both are readily dissolved in warm alcohol, but the latter yields the richer golden-coloured solution. As the alcohol cools, a separation of brilliant scales is perceived. With ether, naphtha, the fixed and volatile oils, the phenomena exhibited by ambergris are absolutely the same as those presented by the concretion with these solvents. The alcoholic solution mixed with liquid ammonia gives a similar milky emulsion.

The *lighter* specimen of ambergris, exposed to a gentle heat over a lamp, in a glass tube sealed at one end, fuses, and evolves a volatile oil in dense vapour, which is condensed on the upper part of the tube. A viscid substance like tar remains at the bottom. The oil resembles the succinic, and has, like it, a disagreeable empyreumatic odour. The *denser* ambergris, being subjected to heat in like circumstances, fuses less readily and completely, emits the same volatile empyreumatic oil, accompanied with crystalline needles, decidedly acidulous. These are either the benzoic or succinic acid. They precipitate peroxide of iron from the neutral red muriate. The smell of the accompanying oil is certainly that of amber; but I have hitherto obtained too small quantities of the acid, to be able to determine to which of the two *it* belongs. The following experiments were made with this view. My first object was to discover a good criterion for discriminating benzoic from succinic acid. In operating necessarily on small quantities, the distinction becomes peculiarly difficult. Both are volatile, crystallizable, and fall down with peroxide of iron, from saline solutions of this metal. After many trials I finally fell on the following plan, which answers very well, even with pretty minute portions. I saturated each acid with ammonia, evaporated to a dry crystalline mass by a gentle heat. Into a small glass tube, sealed at one end, I introduced a portion of the benzoate. The tube was recurved. I exposed the bottom, where the salt was placed, to the heat of a lamp, but very cautiously. Pungent ammoniacal gas was exhaled, and the water of crystallization that distilled over was found strongly impregnated with ammonia. To avoid all fallacy in this result, I slightly supersaturated the ammonia beforehand with the acid. In the middle of the tube, pure benzoic acid was found, in acicular crystals. The succinate of ammonia, on the contrary, sublimes without decomposition.

I now took a few grains of the dense ambergris, digested with alcohol, added water of ammonia, boiled, filtered, and evaporated to dryness. The quantity of saline matter obtained was, however, too minute, even for the above mode of applying an analytical criterion with satisfaction; and being unwilling to consume more than a few grains of a specimen belonging to a public establishment, I preferred waiting till some future opportunity might occur of examining genuine ambergris.

From the lighter, and by its outward appearance, more characteristic specimen of ambergris, I could not obtain even a trace of benzoic acid, though I modified the temperature for sublimation, and other circumstances, in every way I could think of. The oil that rose would not redden the most delicate litmus paper.

In open capsules, fragments of the ambergris, being exposed to a pretty strong heat, exhaled the copious subfœtid smoke; and afterwards burned with the yellow flame exhibited by the concretion. Fragments of the concretions, exposed to heat in a glass tube, fused, envolved the heavy smoke, which condensed into a viscid empyreumatic smelling oil, and in every respect comported itself like the light ambergris.

I therefore must infer it to be a modification of ambergris. It differs decidedly from the adipocere of dead bodies, which forms an emulsion with cold water, is fusible in boiling water, gives a soap with evolution of ammonia when treated with potash, and yields a clear solution, when gently heated, with liquid ammonia. It resembles, however, in many respects, the cholesterine of biliary calculi; and I have no doubt that cholesterine from altered bile is the true origin of ambergris in the whale, as well as of this morbid concretion.

The concretion is almost wholly soluble in hot alcohol; while only one-third of adipocere dissolves in that menstruum at the boiling point.

From ordinary fatty matter it is entirely distinguishable, by its solubility in ether and alcohol, its refusing to combine with alkalis, and the high temperature required for its fusion.

With regard to their place of formation in the animal system, ambergris and this morbid concretion agree. They are both generated in the rectum, or greater intestines. The *physeter macrocephalus* of Linnæus is the species of whale which affords ambergris. In the examination of Captain Coffin before the Privy-Council in 1791, he stated that he found 362 ounces of ambergris in the intestines of a female whale, struck off the coast of Guinea; part of it was voided from the rectum on cutting up the blubber, and the remainder was within the intestinal canal.

The whales that contain ambergris are said to be always lean and sickly, yield but very little oil, and seem almost torpid. Hence, when a spermaceti whale has this appearance, and does not emit feces on being harpooned, the fishers generally expect to find ambergris within it. Whether it be the cause or the effect of disease is problematical, though the latter seems the more rational conjecture. It may in succession be both. The above remarkable fact of the sex of the whale may lead to an inquiry, whether this morbid production, found also in the human subject, be peculiar to females, and connected with lactation.

In the second volume of Dr. Monro's Outlines of the Anatomy of the Human Body in its sound and diseased state, we have the analysis of several alvine concretions by Dr. Thomas Thomson. The results obtained by this eminent chemist show, that the specimens which he examined were of a totally different nature from the preceding concretion.

INULIN. In examining the Inula Hellenium, or Elecampane, Mr. Rose imagined he discovered a new vegetable product, to which the name of Inulin has been given. It is white and pulverulent like starch. When thrown on red-hot coals, it melts, diffusing a white smoke, with the smell of burning sugar. It yields, on distillation in a retort, all the products furnished by gum. It dissolves readily in hot water; and precipitates almost entirely on cooling, in the form of a white powder; but before falling down, it gives the liquid a mucilaginous consistence. It precipitates quickly on the addition of alcohol.

The above substance is obtained by boiling the root of this plant in four times its weight of water, and leaving the liquid in repose. MM. Pelletier and Caventou have found the same starch-like matter in abundance in the root of colchicum; and M. Gautier in the root of pellitory. Starch and inuline combine; and when the former is in excess, it is difficult to separate them. The only method is to pour infusion of galls into the decoction, and then to heat the liquid: if inulin be present, a precipitate will fall, which does not disappear till the temperature rises to upwards of 212° F., while, if only starch be present, it will redissolve at 122° F.

IODINE. A peculiar or undecompounded principle. The investigation of this singular substance will always be regarded as a great era in chemistry. It was then that chemical philosophers first felt the necessity of abandoning Lavoisier's partial and incorrect hypothesis of oxygenation, and of embracing the sound and comprehensive doctrines of Sir H. Davy on chemical theory, first promulgated in his masterly researches on *Chlorine*.

Iodine was accidentally discovered in 1812, by M. de Courtois, a manufacturer of saltpetre at Paris. In his processes for procuring soda from the ashes of sea-weeds, he found the metallic vessels much corroded; and in searching for the cause of the corrosion, he made this important discovery. But for this circumstance, nearly accidental, one of the most curious of substances might have remained for ages unknown, since nature has not distributed it, in either a simple or compound state, through her different kingdoms, but has stored it up to what the Roman satirist considers as the most worthless of things, the vile sea-weed.

Iodine derived its first illustration from MM. Clement and Desormes, names associated always with sound research. In their memoir, read at a meeting of the Institute, these able chemists described its principal properties. They stated its sp. gr. to be about 4; that it becomes a violet-coloured gas at a temperature below that of boiling water; whence its name, 'Ιωδης, *like a violet*, was derived; that it combines with the metals, and with phosphorus and sulphur, and likewise with the alkalis and metallic oxides; that it forms a detonating compound with ammonia; that it is soluble in alcohol, and still more soluble in ether; and that by its action upon phosphorus, and upon hydrogen, a substance having the characters of muriatic acid is formed. In this communication they offered no decided opinion respecting its nature.

In 1813 Sir H. Davy happened to be on a visit to Paris, receiving, amid the political convulsions of France, the tranquil homage due to his genius. "When M. Clement showed iodine to me, he believed that the hydriodic acid was muriatic acid; and M. Gay Lussac, after his early experiments, made originally with M. Clement, formed the same opinion, and *maintained* it, when I *first* stated to him my belief, that it was a new and peculiar acid, and that iodine was a substance analogous in its chemical relations to chlorine." *Sir H. Davy on the Analogies between the undecompounded substances; Journal of Science and the Arts*, vol. i. p. 284.

We see therefore with what intuitive sagacity the English philosopher penetrated the mystery which hung at first over iodine. Its full examination, in its multiplied relations to simple and compound bodies, was immediately entered on with equal ardour by him and M. Gay Lussac. Of the relative merits of the researches, and importance of the results, of these pre-eminent chemists, it is not for me to become an arbiter. I shall content myself with offering a methodical view of the facts brought to light on iodine and the iodides, referring for its other combinations to what I have already stated on the hydriodic and iodic acids.

Iodine has been found in the following sea-weeds, the algæ aquaticæ of Linnæus:—

Fucus cartilagineus,
membranaceus,
filamentosus,
rubens,
nodosus,
serratus,
siliquosus,
Fucus palmatus,
filum,
digitatus,
saccharinus,
Ulva umbilicalis,
pavonia,
linza, and in sponge.

Dr. Fyfe has shown, in an ingenious paper, published in the first volume of the Edin. Phil. Journal, that on adding sulphuric acid to a concentrated viscid infusion of these algæ in hot water, the vapour of iodine is exhaled.

M. Angelina on using starch as a reagent, with the mineral water of Sales in Piedmont, found a blue colour produced in the water, indicating iodine; and he afterwards succeeded in procuring iodine from the water. It is remarkable that for a long time that water has been administered successfully in scrofulous cases, and in cases of the goitre. *Journ. des Mines*, viii. 293.

M. Cantu of Turin found iodine in the sulphureous mineral waters of Castelnuovo d'Asti. He thinks that iodine exists in all the mineral waters that contain chlorides. Yet the sulphureous mineral water of Echaillon in Savoy that yields $\frac{1}{12}$ its weight of common salt contains no iodine. *Ann. de Chim.*, xxviii. 221.

M. Balard gives the following as the best means of testing for iodine. After mixing the liquid containing iodine, with the starch and sulphuric acid, a small quantity of aqueous solution of chlorine is to be added, which from its lightness may be kept floating on the surface. At the place where the two liquids touch, a blue zone will be perceived, which, however feeble it may be, is readily seen by contrast with the adjoining colourless liquids. The colour disappears on agitation, if the chlorine be in excess. By means of this test M. Balard has found iodine, in various marine molluscæ, testaceous or not, such as the *doris*, *venus*, *oysters*, *&c.*, in many polypi and marine vegetables, the *gorgonia*, the *zoster marina*, *&c.*, and especially in the mother waters of the salt pans supplied from the Mediterranean. The iodine of sea-water is in the form of hydriodate.

But the most extraordinary fact concerning the sources of iodine is that lately discovered by M. Vauquelin, of its existence in a mineral brought by M. Tabary from the neighbourhood of Mexico, which was labelled *virgin silver in serpentine*. When this substance was treated with nitric acid, boiled for some time, and then diluted, two insoluble portions appeared; one very heavy and falling instantly, which when digested in hot muriatic acid evolved the violet vapour of iodine. The acid mixture diluted had the power of tingeing starch of the usual purple blue. 100 parts of the above mineral afforded 18·5 of iodine. Pump wells and springs in the neighbourhood of waste soap works, where kelp has been long accumulated, are necessarily impregnated with iodine, which may in such cases be detected by M. Balard's process. *Ann. de Chim.* xxix. 99.

But it is from the incinerated sea-weed or kelp, that iodine in quantities is to be obtained. Dr. Wollaston first communicated a precise formula for extracting it. Dissolve the soluble part of kelp in water. Concentrate the liquid by evaporation, and separate all the crystals that can be obtained. Pour the remaining liquid into a clean vessel, and mix with it an excess of sulphuric acid. Boil this liquid for some time. Sulphur is precipitated, and muriatic acid driven off. Decant off the clear liquid, and strain it through wool. Put it into a small flask, and mix it with as much black oxide of manganese as we used before of sulphuric acid. Apply to the top of the flask a glass tube, shut at one end. Then heat the mixture in the flask. The iodine sublimes into the glass tube. None can be obtained from sea-water.

In repeating this process with care, I obtained from similar quantities of kelp such variable products of iodine, that I was induced to institute a series of experiments in 1814, for discovering the causes of these anomalies, and for procuring iodine at an easier rate. The result, which was successful, I communicated to the world in the 50th volume of the Philosophical Magazine. Instead of procuring this interesting element in only a few grains, I have been able to extract ounces at a time, and at a moderate expense. I shall here transcribe the outlines of my method.

As several of the Scotch soap manufacturers use scarcely any other alkaline matter for their hard soaps except kelp, it occurred to me that in some of their residuums a substance might be found rich in iodine. Accordingly, after some investigation, I found a brown liquid, of an oily consistence, from which I expected to procure what I wanted; and I therefore instituted a series of experiments on the best mode of extraction.

The specific gravity of this liquid, as obtained at different times, is pretty uniformly 1.374. It converts vegetable blues to green, thus indicating free alkali. Of this the manufacturer is aware, for he returns the liquid occasionally into his kelp leys. Its boiling point is 233° Fahr. Eight ounces apothecaries' measure require precisely one measured ounce of sulphuric acid for their neutralization. Supposing this quantity of acid combined with soda, it would indicate one part of pure soda in eleven by weight of the liquid. But the chief part of the alkali is not uncombined; for an immense quantity of sulphurous acid, and a little sulphuretted hydrogen gases, escape during the affusion of the sulphuric acid.

"100 grains of the liquid yield 3.8 cubic inches of gas, chiefly sulphurous acid, and sulphur is at the same time deposited. From this last circumstance one would expect a greater proportion of sulphuretted hydrogen; but the disengaged gas possesses the peculiar smell and pungency of burning sulphur, blanches the petals of the red rose, but shows scarcely any action on paper dipped in saturnine solutions. On the instant of decomposition of the sulphite and hydroguretted sulphuret of soda existing in the liquid, the nascent sulphurous acid of the former may be supposed to decompose the nascent sulphuretted hydrogen of the latter; their atoms of oxygen and hydrogen uniting, with precipitation of the sulphur. I can in no other way account for the very copious separation of sulphur, while very little sulphuretted hydrogen appears." I now find the liquid to contain hyposulphite of soda.

From 8 liquid ounces = 11 by weight, 213 grains of sulphur are obtained. The saturated liquid has a specific gravity of 1·443, a bright yellow colour, and does not change the purple colour of infusion of red cabbage.

Having described the substance which I used, I shall now state, in a few words, the best method of taking the iodine out of it:—

"The brown iodic liquid of the soap-boiler was heated to about 230° F., poured into a large stone-ware basin, of which it filled about one-half, and saturated by the addition of the suitable quantity of sulphuric acid as above stated. It is advantageous to dilute the acid previously, with its own bulk of water*. On cooling the mixture, a large quantity of saline crystals is found adhering to the sides and bottom of the vessel. These are chiefly sulphate of soda, with a very little sulphate of potash, and a few beautiful oblong rhomboidal plates of hydriodate of soda. Sulphur is mixed with these crystals.

"Filter the above cold liquid through woollen cloth. To every 12 oz. apothecaries' measure, add 1000 grains of black oxide of manganese in powder. Put this mixture into a glass globe, or large matrass with a wide neck, over which a glass globe is inverted, and apply heat with a charcoal chauffer. The less diffusive flame of a lamp is apt to crack the bottom of the matrass; particularly if a large quantity of materials be employed. To prevent the heat from acting on the globular receiver, a thin disc of wood, having a round hole in its centre, is placed over the shoulder of the matrass.

"Iodine now sublimes very copiously, and is readily condensed in the upper vessel. As soon as this becomes warm, another is to be put in its place; and thus the two may be applied in rotation, as long as the violet vapour rises.

"From the above quantity of liquid, by this treatment, I obtain from 80 to 100 grains of iodine, perfectly pure. It is withdrawn from the globes most conveniently by a little water, which dissolves iodine very sparingly, as is well known. It may be purified by a second sublimation.

"If the manganese be increased much beyond the above proportion, the product of iodine is greatly decreased. If thrice the quantity be used, for example, a furious effervescence takes place, nearly the whole mixture is thrown out of the matrass, with a kind of explosive violence, and hardly any iodine is procured, even though the materials should be saved by the relatively large capacity of the vessel that contains them. If, on the other hand, one-half of the prescribed quantity of manganese be used, much hydriodic acid rises along with the iodine, and washes it perpetually down the sides of the balloon. Or if, during the proper and successful sublimation of iodine, the weight of manganese be doubled, the violet vapours instantly cease. Nor will zinc filings, sugar or starch, restore to the mixture the power of exhaling the iodine.

"The same interruption of the process is occasioned by using an excess of sulphuric acid. For, if to the mixture of 12 oz. of saturated liquid, with 1000 or 1100 grains manganese, an additional half ounce measure of sulphuric acid be poured in, the violet vapour disappears, and the sublimation of iodine is at an end. Quicklime now added so as to saturate the excess of acid will not restore the production of iodine.

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* When concentrated acid is added, the effervescence is very violent; the liquid reddens wherever the acid falls, and a little purple vapour of iodine rises.

"The best subliming temperature is 232° F.

"Iodine, in open vessels, readily evaporates at much lower temperatures, even at the usual atmospheric heats. When it is spread thin on a plate of glass, if the eye be placed in the same plane, the violet vapour becomes very obvious at the temperature of 100° F. If left in the open air, it will speedily evaporate altogether away, even at 50° or 60°. When kept in a phial stopped with a common cork the iodine also disappears, while the cork will become friable in its texture, and of a brownish-yellow colour.

"240 grains of nitric acid, specific gravity 1.490, saturate 1000 grains of the brown liquid. Sulphurous acid is abundantly exhaled as before. After filtration, a bright golden coloured liquid is obtained. On adding to this liquid a little manganese, iodine sublimes; but the quantity procurable in this way seems to be proportionally less than by the sulphuric acid."

I have described a new form of apparatus, for sublimation, in the above paper, by which beautiful crystals may easily be procured, without risk of injuring their form.

Iodine is a solid, of a greyish-black colour and metallic lustre. It is often in scales similar to those of micaceous iron ore, sometimes in rhomboidal plates, very large and very brilliant. It has been obtained in elongated octohedrons, nearly half an inch in length; the axes of which were shown by Dr. Wollaston to be to each other, as the numbers 2, 3, and 4, at least so nearly, that in a body so volatile, it is scarcely possible to detect an error in this estimate, by the reflective goniometer. Its fracture is lamellated, and it is soft and friable to the touch. Its taste is very acrid, though it be very sparingly soluble in water. It is a deadly poison. It gives a deep brown stain to the skin, which soon vanishes by evaporation. In odour, and power of destroying vegetable colours, it resembles very dilute aqueous chlorine. The sp. gr. of iodine at 62½° is 4.948. It dissolves in 7000 parts of water. The solution is of an orange-yellow colour, and in small quantity tinges raw starch of a purple hue.

It melts, according to M. Gay Lussac, at 227° F. and is volatilized under the common pressure of the atmosphere at the temperature of 350°. By my experiments, it evaporates pretty quickly at ordinary temperatures. Boiling water aids its sublimation, as is shown in the above process of extraction. The sp. gr. of its violet vapour is 8.678. It is a non-conductor of electricity. When the voltaic chain is interrupted by a small fragment of it, the decomposition of water instantly ceases.

Iodine is incombustible, but with azote it forms a curious detonating compound; and in combining with several bodies, the intensity of mutual action is such as to produce the phenomena of combustion. Its combinations with oxygen and chlorine have been already described, under iodic and chloriodic acids.

With a view of determining whether it was a simple or compound form of matter, Sir H. Davy exposed it to the action of the highly inflammable metals. When its vapour is passed over potassium heated in a glass tube, inflammation takes place, and the potassium burns slowly with a pale blue light. There was no gas disengaged when the experiment was repeated in a mercurial apparatus. The iodide of potassium is white, fusible at a red heat, and soluble in water. It has a peculiar acrid taste. When acted on by sulphuric acid, it effervesces, and iodine appears. It is evident that in this experiment there had been no decomposition; the result depending merely on the combination of iodine with potassium. By passing the vapour of iodine over dry red-hot potash, formed from potassium, oxygen is expelled, and the above iodide results. Hence we see, that at the temperature of ignition, the affinity between iodine and potassium is superior to that of the latter for oxygen. But iodine in its turn is displaced by chlorine, at a moderate heat, and if the latter be in excess, chloriodic acid is formed. M. Gay Lussac passed vapour of iodine in a red heat over melted subcarbonate of potash; and he obtained carbonic acid and oxygen gases, in the proportions of two in volume of the first and one of the second, precisely those which exist in the salt.

The oxide of sodium, and the subcarbonate of soda, are also completely decomposed by iodine. From these experiments it would seem, that this substance ought to disengage oxygen from most of the oxides; but this happens only in a small number of cases. The protoxides of lead and bismuth are the only oxides, not reducible by mere heat, with which it exhibited that power. Barytes, strontian, and lime, combine with iodine, without giving out oxygen gas, and the oxides of zinc and iron undergo no alteration in this respect. From these facts we must conclude, that the decomposition of the oxides by iodine depends less on the condensed state of the oxygen than upon the affinity of the metal for iodine. Except barytes, strontian, and lime, no oxide can remain in combination with iodine at a red heat. For a more particular account of some iodides, see ACID (HYDRIODIC); the compounds of which, in the liquid or moist state, are hydriodates, but change, on drying, into iodides, in the same way as the muriates become chlorides.

From the proportion of the constituents in hydriodic acid, 15.5 has been deduced as the prime equivalent of iodine.

M. Gay Lussac says, "Sulphate of potash

was not altered by iodine; but, what may appear astonishing, I obtained oxygen with the fluate of potash, and the glass tube in which the operation was conducted was corroded. On examining the circumstances of the experiment, I ascertained that the fluate became alkaline when melted in a platinum crucible. This happened to the fluate over which I passed iodine. It appears then that the iodine acts upon the excess of alkali, and decomposes it. The heat produced disengages a new portion of fluoric acid or its radical, which corrodes the glass; and thus by degrees the fluate is entirely decomposed." These facts seem to give countenance to the opinion, that the fluoric is an oxygen acid; and that the salt called fluate of potash is not a fluoride of potassium. See ACID (FLUORIC).

Iodine forms with sulphur a feeble compound, of a greyish-black colour, radiated like sulphuret of antimony. When it is distilled with water, iodine separates.

Iodine and phosphorus combine with great rapidity at common temperatures, producing heat without light. From the presence of a little moisture, small quantities of hydriodic acid gas are exhaled.

Oxygen expels iodine from both sulphur and phosphorus.

"Hydrogen, whether dry or moist, did not seem," says M. Gay Lussac, "to have any action on iodine at the ordinary temperature; but if, as was done by M. Clement in an experiment at which I was present, we expose a mixture of hydrogen and iodine to a red heat in a tube, they unite together, and hydriodic acid is produced, which gives a reddish brown colour to water." Sir H. Davy, with his characteristic ingenuity, threw the violet-coloured gas upon the flame of hydrogen, when it seemed to support its combustion. He also formed a compound of iodine with hydrogen, by heating to redness the two bodies in a glass tube. See ACID (HYDRIODIC).

Charcoal has no action upon iodine, either at a high or low temperature. Several of the common metals, on the contrary, as zinc, iron, tin, mercury, attack it readily, even at a low temperature, provided they be in a divided state. Though these combinations take place rapidly, they produce but little heat, and but rarely any light.

The compound of iodine and zinc, or iodide of zinc, is white. It melts readily, and is sublimed in the state of fine acicular four-sided prisms. It is very soluble in water, and rapidly deliquesces in the air. It dissolves in water, without the evolution of any gas. The solution is slightly acid, and does not crystallize. The alkalis precipitate from it white oxide of zinc; while concentrated sulphuric acid disengages hydriodic acid and iodine, because sulphurous acid is produced. The solution is a hydriodate of oxide of zinc. When iodine and zinc are made to act on each other under water in vessels hermetically sealed, on the application of a slight heat, the water assumes a deep reddish-brown colour, because, as soon as hydriodic acid is produced, it dissolves iodine in abundance. But by degrees the zinc, supposed to be in excess, combines with the whole iodine, and the solution becomes colourless like water.

Iron is acted on by iodine in the same way as zinc; and a brown iodide results, which is fusible at a red heat. It dissolves in water, forming a light green solution, like that of muriate of iron. When the dry iodide was heated, by Sir H. Davy, in a small retort containing pure ammoniacal gas, it combined with the ammonia, and formed a compound which volatilized without leaving any oxide.

The iodide of tin is very fusible. When in powder, its colour is a dirty orange-yellow, not unlike that of glass of antimony. When put into a considerable quantity of water, it is completely decomposed. Hydriodic acid is formed, which remains in solution in the water, and the oxide of tin precipitates in white flocculi. If the quantity of water be small, the acid, being more concentrated, retains a portion of oxide of tin, and forms a silky orange-coloured salt, which may be almost entirely decomposed by water. Iodine and tin act very well on each other, in water of the temperature of 212°. By employing an excess of tin, we may obtain pure hydriodic acid, or at least an acid containing only traces of the metal. The tin must be in considerable quantity, because the oxide which precipitates on its surface, diminishes very much its action on iodine.

Antimony presents, with iodine, the same phenomena as tin; so that we might employ either for the preparation of hydriodic acid, if we were not acquainted with preferable methods.

The iodides of lead, copper, bismuth, silver, and mercury, are insoluble in water, while the iodides of the very oxidizable metals are soluble in that liquid. If we mix a hydriodate with the metallic solutions, all the metals which do not decompose water will give precipitates, while those which decompose that liquid will give none. This is at least the case with the above mentioned metals.

There are two iodides of mercury; the one yellow, the other red: both are fusible and volatile. The yellow or protiodide, contains one half less iodine than the deutiodide. The latter, when crystallized, is a bright crimson. In general there ought to be for each metal as many iodides as there are oxides and chlorides. All the iodides are decomposed by concentrated sulphuric and nitric acids. The metal is converted into an oxide, and iodine is disengaged. They are likewise decomposed by oxygen at a red heat, if we except the iodides of potassium, sodium, lead, and bismuth. Chlorine likewise separates iodine from all the iodides; but iodine, on the other hand, decomposes most of the sulphurets and phosphurets.

When iodine and oxides act upon each other in contact with water, very different results take place from those above described. The water is decomposed; its hydrogen unites with iodine, to form hydriodic acid; while its oxygen, on the other hand, produces with iodine, iodic acid. All the oxides, however, do not give the same results. We obtain them only with potash, soda, barytes, strontian, lime, and magnesia. The oxide of zinc, precipitated by ammonia from its solution in sulphuric acid, and well washed, gives no trace of iodate and hydriodate.

We shall treat of the compound of iodine and azote under the article Nitrogen.

From all the above recited facts, we are warranted in concluding iodine to be *an undecompounded body*. In its specific gravity, lustre, and magnitude of its prime equivalent, it resembles the metals; but in all its chemical agencies, it is analogous to oxygen and chlorine. It is a non-conductor of electricity, and possesses, like these two bodies, the negative electrical energy with regard to metals, inflammable and alkaline substances; and hence, when combined with these substances in aqueous solution, and electrized in the voltaic circuit, it separates at the positive surface. But it has a positive energy with respect to chlorine; for when united to chlorine, in the chloriodic acid, it separates at the negative surface. This likewise corresponds with their relative attractive energy, since chlorine expels iodine from all its combinations. Iodine dissolves in carburet of sulphur, giving, in very minute quantities, a fine amethystine tint to the liquid.

Iodide of mercury has been proposed for a pigment. M. Orfila swallowed 6 grains of iodine; and was immediately affected with heat, constriction of the throat, nausea, eructation, salivation, and cardialgia. In ten minutes he had copious bilious vomitings, and slight colic pains. His pulse rose from 70 to about 90 beats in the minute. By swallowing large quantities of mucilage, and emollient clysters, he recovered, and felt nothing next day but slight fatigue. About 70 or 80 grains proved a fatal dose to dogs. They usually died on the fourth or fifth day.

Dr. Coindet of Geneva has recommended the use of iodine in the form of tincture, and also hydriodate of potash or soda, as an efficacious remedy for the cure of glandular swellings, of the goitrous and scrophulous kind. I have found an ointment composed of 1 oz. hog's lard, and 1 drachm of iodide of zinc, a powerful external application in such cases. About a drachm of this ointment should be used in friction on the swelling once or twice a-day.

IOLITE. Prismato-rhomboidal quartz of Mohs. Colour intermediate between violet-blue and blackish-blue. When viewed in the direction of the axis of the crystals, the colour is dark indigo-blue; but perpendicular to the axis of the crystals, pale brownish-yellow. Massive, disseminated, rarely crystallized in six-sided prisms. Lustre vitreous. Fracture small grained, uneven. Refracts double. Sp. gr. 2.5 to 2.6. Easily frangible. Its constituents are, silica 43.6, alumina 37.6, magnesia 9.7, potash 1, oxide of iron 4.5, oxide of manganese a trace.—*Gmelin.* It occurs in primitive rocks at Orijarvi, near Abo in Finland. It is cut and polished for a gem.—*Jameson.*

IPECACUAN. See Emetin.

IRIDIUM. Mr. Tennant, on examining the black powder left after dissolving platina, which from its appearance had been supposed to consist chiefly of plumbago, found it contained two distinct metals, never before noticed, which he has named iridium and osmium. The former of these was observed soon after by Descostils, and by Vauquelin.

To analyze the black powder, Mr. Tennant put it into a silver crucible, with a large proportion of pure dry soda, and kept it in a red heat for some time. The alkali being then dissolved in water, it had acquired a deep orange or brownish-yellow colour, but much of the powder remained undissolved. This digested in muriatic acid gave a dark-blue solution, which afterwards became of a dusky olive-green; and finally, by continuing the heat, of a deep red. The residuum being treated as before with alkali, and so on alternately, the whole appeared capable of solution. As some silex continued to be taken up by the alkali till the whole of the metal was dissolved, it seems to have been chemically combined with it. The alkaline solution contains oxide of osmium, with a small proportion of iridium, which separates spontaneously in dark-coloured thin flakes by keeping it some weeks.

The acid solution contains likewise both the metals, but chiefly iridium. By slow evaporation, it affords an imperfectly crystallized mass; which being dried on blotting-paper, and dissolved in water, gives by evaporation distinct octohedral crystals. These crystals, dissolved in water, produce a deep red solution, inclining to orange. Infusion of galls occasions no precipitate, but instantly renders the solution almost colourless. Muriate of tin, carbonate of soda, and prussiate of potash, produce nearly the same effect. Ammonia precipitates the oxide, but, possibly from being in excess, retains a part in solution, acquiring a purple colour. The fixed alkalis precipitate the greater part of the oxide, but retain a part in solution, this becoming yellow. All the metals that Mr. Tennant tried, except gold and platina, produced a dark or black precipitate from the muriatic solution, and left it colourless.

The iridium may be obtained pure, by exposing the octohedral crystals to heat, which expels the oxygen and muriatic acid. It was white, and could not be melted by any heat

Mr. Tennant could employ. It did not combine with sulphur, or with arsenic. Lead unites with it easily, but is separated by cupellation, leaving the iridium on the cupel as a coarse black powder. Copper forms with it a very malleable alloy, which, after cupellation, with the addition of lead, leaves a small proportion of the iridium, but much less than in the preceding instance. Silver forms with it a perfectly malleable compound, the surface of which is tarnished merely by cupellation; yet the iridium appears to be diffused through it in fine powder only. Gold remains malleable, and little altered in colour, though alloyed with a considerable proportion; nor is it separable either by cupellation or quartation. If the gold or silver be dissolved, the iridium is left as a black powder.

The French chemists observed, that this new metal gave a red colour to the triple salt of platina and sal ammoniac, was not altered by muriate of tin, and was precipitated of a dark brown by caustic alkali. Vauquelin added, that it was precipitated by galls, and by prussiate of potash; but Mr. Tennant ascribes this to some impurity.

Mr. Tennant gave it the name of iridium, from the striking variety of colours it affords while dissolving in muriatic acid.

Dr. Wollaston has observed, that among the grains of crude platina, there are some scarcely distinguishable from the rest but by their insolubility in nitro-muriatic acid. They are harder, however, when tried by the file; not in the least malleable; and of the specific gravity of 19·5. These appeared to him to be an ore, consisting entirely of the two new metals.

Vauquelin has since succeeded in forming sulphuret of iridium, by heating a mixture of ammonia-muriate of iridium and sulphur. It is a black powder consisting of 100 iridium + 33·3 sulphur; whence, supposing it a neutral compound, the prime equivalent of iridium would be 6·0. The same chemist has also alloyed iridium with lead, copper, and tin. They are all malleable; and considerably hardened by the presence of the iridium.

IRON is a metal of a bluish-white colour, of considerable hardness and elasticity; very malleable, and exceedingly tenacious and ductile. This metal is easily oxidized. A piece of iron wire, immersed in a jar of oxygen gas, being ignited at one end, will be entirely consumed by the excessive combustion of its parts. It requires a very intense heat to fuse it; on which account it can only be brought into the shape of tools and utensils by hammering. This high degree of infusibility would deprive it of the most valuable property of metals, namely, the uniting of smaller masses into one, if it did not possess another singular and advantageous property, which is found in no other metal except platina; namely, that of welding. In a white heat, iron appears as if covered with a kind of varnish; and in this state if two pieces be applied together, they will adhere, and may be perfectly united by forging.

When iron is exposed to the action of moist air or water, it acquires weight by gradual oxidation, and hydrogen gas escapes: this is a very slow operation. But if the steam of water be made to pass through a red-hot gun-barrel, or through an ignited copper or glass tube, containing iron wire, the iron becomes converted into an oxide, while hydrogen gas passes out at the other end of the barrel. By the action of stronger heat this becomes a reddish-brown oxide. The yellow rust, formed when iron is long exposed to damp air, is not a simple oxide, as it contains a portion of carbonic acid.

The concentrated sulphuric acid scarcely acts on iron, unless it is boiling. If the acid be diluted with two or three parts of water, it dissolves iron readily, without the assistance of heat. During this solution, hydrogen escapes in large quantities.

The green sulphate of iron is much more soluble in hot than cold water; and therefore crystallises by cooling as well as by evaporation. The crystals are efflorescent, and fall into a white powder by exposure to a dry air, the iron becoming more oxidized than before. A solution of sulphate of iron, exposed to the air, imbibes oxygen; and a portion of the iron becoming peroxidized, falls to the bottom.

Sulphate of iron is not made in the direct way, because it can be obtained at less charge from the decomposition of martial pyrites. It exists in two states, one containing oxide of iron, with 0·22 of oxygen, which is of a pale green, not altered by gallic acid, and giving a white precipitate with prussiate of potash. The other, in which the iron is combined with 0·30 of oxygen, is red, not crystallizable, and gives a black precipitate with gallic acid, and a blue with prussiate of potash. In the common sulphate, these two are often mixed in various proportions.

Sulphate of iron is decomposed by alkalis and by lime. Caustic fixed alkali precipitates the iron in deep green flocks, which are partially dissolved by the addition of more alkali, and form a red tincture.

Vegetable astringent matters, such as nutgalls, the husks of nuts, logwood, tea, &c. which contain tannin and gallic acid, precipitate a fine black fecula from sulphate of iron, which remains suspended for a considerable time in the fluid, by the addition of gum-arabic. This fluid is well known by the name of ink. See INK.

The beautiful pigment, well known in the arts by the name of prussian blue, is likewise a precipitate afforded by sulphate of iron.

Concentrated nitric acid acts very strongly upon iron filings, much nitrous gas being disengaged at the same time. The solution is of a reddish-brown, and deposits the oxide of iron after a certain time; more especially if the vessel be left exposed to the air. A diluted nitric acid affords a more permanent solution of iron, of a greenish colour, or sometimes of a yellow colour. Neither of the solutions affords crystals, but both deposit the oxide of iron by boiling, at the same time that the fluid assumes a gelatinous appearance.

Diluted muriatic acid rapidly dissolves iron at the same time that a large quantity of hydrogen is disengaged, and the mixture becomes hot.

If iron filings be triturated with muriate of ammonia, moistening the mixture; then drying, powdering, and again triturating; and lastly subliming with a heat quickly raised; yellow or orange-coloured flowers will rise, consisting of a mixture of muriate of ammonia, with more or less muriate of iron. These, which were called *flowers of steel*, and still more improperly *ens veneris*, were once much esteemed; but are now little used, as they are nauseous in solution, and cannot very conveniently be given in any other form.

Carbonic acid, dissolved in water, combines with a considerable quantity of iron, in proportion to its mass.

Phosphoric acid unites with iron, but very slowly. The union is best effected by adding an alkaline phosphate to a solution of one of the salts of iron, when it will fall down in a white precipitate. This acid is found combined with iron in the bog ores, and being at first taken for a peculiar metal, was called *siderite* by Bergmann.

Liquid fluoric acid attacks iron with violence: the solution is not crystallizable, but thickens to a jelly, which may be rendered solid by continuing the heat. The acid may be expelled by heating it strongly, leaving a fine red oxide.

Borate of iron may be obtained by precipitating a solution of the sulphate with neutral borate of soda.

Arsenic acid likewise unites with iron. This arseniate is found native.

Chromate of iron has been found in the department of Var in France, and elsewhere. This is, however, rather a compound of the oxides of iron and chrome.

Sulphur combines very readily with iron. A mixture of iron filings and flowers of sulphur being moistened, or made into a paste with water, becomes hot, swells, adheres together, breaks, and emits watery vapours of an hepatic smell. If the mixture be considerable in quantity, as for example, one hundred pounds, it takes fire in twenty or thirty hours, as soon as the aqueous vapours cease.

By fusion with iron, sulphur produces a compound of the same nature as the pyrites, and exhibiting the same radiated structure when broken. If a bar of iron be heated to whiteness, and then touched with a roll of sulphur, the two substances combine, and drop down together in a fluid state. Mr. Hatchett found, that the magnetical pyrites contains the same proportion as the artificial protosulphuret.

Phosphorus may be combined with iron by adding it, cut into small pieces, to fine iron wire heated moderately red in a crucible; or by fusing six parts of iron clippings, with six of glacial phosphoric acid, and one of charcoal powder. This phosphuret is magnetic; and Mr. Hatchett remarks, that iron, which in its soft or pure state cannot retain magnetism, is enabled to do so when hardened by carbon, sulphur, or phosphorus, unless the dose be so great as to destroy the magnetic property, as in most of the natural pyrites and plumbago.

The combination of carbon with iron is of all the most important, and under the names of Cast-Iron and Steel will be considered in the latter part of the present article.

Iron unites with gold, silver, and platina. When heated to a white-heat, and plunged in mercury, it becomes covered with a coating of that metal. Mr. A. Aitken unites an amalgam of zinc and mercury with iron filings, and then adds muriate of iron, when a decomposition takes place, the muriatic acid combining with the zinc, and the amalgam of iron and mercury assuming the metallic lustre by kneading, assisted with heat. Iron and tin very readily unite together. Iron does not unite easily with bismuth, at least in the direct way. This alloy is brittle and attractible by the magnet, even with three-fourths of bismuth. As nickel cannot be purified from iron without the greatest difficulty, it may be presumed that these substances readily unite. Arsenic forms a brittle substance in its combination with iron. Cobalt forms a hard mixture with iron, which is not easily broken. Manganese is almost always united with iron in the native state. Tungsten forms a brittle, whitish-brown, hard alloy, of a compact texture, when fused with white crude iron. The habitudes of iron with molybdena are not known.

Iron is the most diffused, and the most abundant of metallic substances. Few mineral bodies or stones are without an admixture of this metal. Sands, clays, the waters of rivers and springs, are scarcely ever perfectly free from it. The parts of animal and vegetable substances likewise afford iron in the residues they leave after incineration. It has been found native, in large masses, in Siberia, and in the internal parts of South America. This metal, however, in its native state is scarce: most iron is found in the state of oxide, in ochres, bog ores, and other friable earthy substances, of a red, brown, yellow, or black colour. The magnet or loadstone is an iron ore. Iron is also found in combination with the sulphuric acid, either dissolved in water, or in the form of sulphate.

In the large iron-works, it is usual to roast or calcine the ores of iron, previous to their fusion; as well for the purpose of expelling sulphureous or arsenical parts, as to render them more easily broken into fragments of a convenient size for melting. The mineral is melted or run down, in large furnaces, from 16 to 30 feet high; and variously shaped, either conical or elliptical, according to the opinion of the iron-master. Near the bottom of the furnace is an aperture for the insertion of the pipe of large bellows, worked by water or steam, or of other machines for producing a current of air; and there are also holes at proper parts of the edifice, to be occasionally opened, to permit the scoriæ and the metal to flow out, as the process may require. Charcoal or coak, with lighted brushwood, is first thrown in; and when the whole inside of the furnace has acquired a strong ignition, the ore is thrown in by small quantities at a time, with more of the fuel, and commonly a portion of limestone as a flux: the ore gradually subsides into the hottest part of the furnace, where it becomes fused; the earthy part being converted into a kind of glass; while the metallic part is reduced by the coal, and falls through the vitreous matter to the lowest place. The quantity of fuel, the additions, and the heat, must be regulated in order to obtain iron of any desired quality; and this quality must likewise, in the first product, be necessarily different, according to the nature of the parts which compose the ore.

The iron which is obtained from the smelting furnaces is not pure; and may be distinguished into three states: white crude iron, which is brilliant in its fracture, and exhibits a crystallized texture, more brittle than the other kinds, not at all malleable, and so hard as perfectly to withstand the file: grey crude iron, which exhibits a granulated and dull texture when broken; this substance is not so hard and brittle as the former, and is used in the fabrication of artillery, and other articles which require to be bored, turned, or repaired: and black cast iron, which is still rougher in its fracture; its parts adhere together less perfectly than those of the grey crude iron.

In order to convert it into malleable iron, it is placed on a hearth, in the midst of charcoal, urged by the wind of two pair of bellows. As soon as it becomes fused, a workman continually stirs it with a long iron instrument. During the course of several hours it becomes gradually less fusible, and assumes the consistence of paste. In this state it is carried to a large hammer, the repeated blows of which drive out all the parts that still partake of the nature of crude iron so much as to retain the fluid state. By repeated heating and hammering, more of the fusible iron is forced out; and the remainder, being malleable, is formed into a bar or other form for sale. Crude iron loses upwards of one-fourth of its weight in the process of refining; sometimes indeed one-half.

Purified or bar iron is soft, ductile, flexible, malleable, and possesses all the qualities which have been enumerated under this article as belonging exclusively to iron. When a bar of iron is broken, its texture appears fibrous; a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition destroys this fibrous texture, and renders the iron more uniform throughout; but hammering restores it.

If the purest malleable iron be bedded in pounded charcoal, in a covered crucible, and kept for a certain number of hours in a strong red heat, (which time must be longer or shorter, according to the greater or less thickness of the bars of iron), it is found, that by this operation, which is called cementation, the iron has gained a small addition of weight, amounting to about the hundred and fiftieth or the two-hundredth part; and is remarkably changed in its properties. It is much more brittle and fusible than before. Its surface is commonly blistered when it comes out of the crucible; and it requires to be forged, to bring its parts together into a firm and continuous state. This cemented iron is called steel. It may be welded like bar iron, if it have not been fused, or over-cemented; but its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water. The hardness produced is greater in proportion as the steel is hotter, and the water colder. The colours which appear on the surface of steel slowly heated are yellowish-white, yellow, gold colour, purple, violet, deep blue, yellowish-white; after which the ignition takes place. These signs direct the artist in tempering or reducing the hardness of steel to any determinate standard. If steel be too hard, it will not be proper for tools which are intended to have a fine edge, because it will be so brittle, that the edge will soon become notched; if it be too soft, it is evident that the edge will bend or turn. Some artists ignite their tools, and plunge them into cold water; after which, they brighten the surface of the steel upon a stone: the tool being then laid upon charcoal, or upon the surface of melted lead, or placed in the flame of a candle, gradually acquires the desired colour; at which instant they plunge it into water. If a hard temper be desired, the piece is dipped again, and stirred about in the cold water as soon as the yellow tinge appears. If the purple appear before the dipping, the temper will be fit for gravers, and tools used in working upon metals; if dipped while blue, it will be proper for springs, and for instruments used in the cutting of soft substances, such as cork, leather, and the like; but if the last pale colour be waited for, the hardness of the steel will scarcely exceed that of iron. When soft steel is heated to any one of these colours, and then plunged into water, it does not acquire nearly so great a degree of hardness, as if previously made quite hard, and then reduced by tempering. The degree of ignition required to harden steel is different in the different kinds. The best kinds require only a low red heat. The harder the steel, the more coarse and granulated its fracture will be; and as this is not completely remedied by the subsequent tempering, it is advisable to employ the least heat capable of affording the requisite hardness.

The usual time required for the cementation of steel is from six to ten hours. If the cementation be continued too long, the steel becomes porous, brittle, of a darker fracture, more fusible, and incapable of being forged or welded. On the contrary, steel cemented with earthy infusible powders, is gradually reduced to the state of forged iron again. Simple ignition produces the same effect; but is attended with oxidation of the surface. The texture of steel is rendered more uniform by fusing it before it is made into bars: this is called cast steel; and is rather more difficultly wrought than common steel, because it is more fusible, and is dispersed under the hammer if heated to a white heat.

The English steel made by cementation, and afterward fused, and sold under the name of cast steel, in bars, plates, and other forms, possesses great reputation for its uniformity of texture, and other good qualities. I have been informed by various authorities, of which the respectability and connexions are calculated to produce the most absolute confidence, that all the prime steels of England are made from Swedish iron, known in this country by the name of steel iron, of three different marks, the first of which indicates the best quality, and the third the worst.

The conversion of iron into steel, either by fusion, viz. the direct change of crude iron into steel, or by cementation of bar iron, presents many objects of interesting inquiry. From various experiments of Bergmann it appeared, that good crude iron, kept for a certain time in a state of fusion, with such additions as appeared calculated to produce little other effect than that of defending the metal from oxidation, became converted into steel with loss of weight. These facts are conformable to the general theory of Vandermonde, Monge, and Berthollet: for, according to their researches, it should follow that part of the carbon in the crude iron was dissipated, and the remainder proved to be such in proportion as constitutes steel. The same chemist cemented crude iron with plumbago, or carbonate of iron, and found that the metal had lost no weight. Morveau repeated the experiment with grey crude iron. The loss of weight was little, if any. The metal exhibited the black spot by the application of nitric acid, as steel usually does, but it did not harden by ignition and plunging in water. Hence I conclude, that it was scarcely altered; for crude irons also exhibit the black spot, and cannot by common management acquire the hardness of steel.

By pursuing this train of reflection, it will follow, that, since crude iron differs from steel only in the superabundance of carbon, it ought to be capable of extreme hardness, if ignited to that degree which is requisite to combine the greater part of this carbon with the iron, and then suddenly cooled. This is accordingly found to be the case. If the grey crude iron, commonly distinguished by our founders by the name of soft metal, be heated to a white heat, and then plunged into water, it becomes very hard, much whiter, denser, and more metallic in its appearance; and will bear a pretty good edge fit for gravers, for the use of turners in iron or steel. In these tools the angle of the planes which form the edge is about 45°. The hardness of this kind of iron is not considerably diminished but by ignition continued for a length of time, which is a fact also conformable to what happens in steel. For the cast steel will be softened nearly as much by annealing to the straw colour, as the harder steels are by annealing to a purple or full blue.

Some of our artists have taken advantage of this property of soft crude iron in the fabrication of axles and collars for wheelwork; for this material is easily filed and turned in its soft state, and may afterward be hardened so as to endure a much longer time of wear.

The founders who cast wheels and other articles of mechanism are occasionally embarrassed by this property. For, as the metal is poured into their moulds of moistened sand, the evaporation of the water carries off a great portion of the heat, and cools the iron so speedily, as to render it extremely hard, white, and close in its texture. This is most remarkable in such portions of the metal as have the greatest distance to run from the git or aperture of reception. For these come in contact successively with a larger portion of the sand, and are therefore more suddenly cooled. I have seen the teeth of cog-wheels altogether in this state, while the rim and other parts of the wheel remained soft. The obvious remedy for this defect is to increase the number of gits, and to have the sand as dry as possible or convenient. In other articles this property has been applied to advantage, particularly in the steel rollers for large laminating mills.

I have been informed by a workman, that ignited iron, suddenly plunged into the soft leather of a shoe, becomes very hard on its surface, which must arise from an instantaneous effect of case-hardening.

The increase of dimensions acquired by steel in hardening is such, that, in general, pieces of work finished soft will not fit their places when hardened.

The fineness of grain in hard steel, as exhibited in its fracture, is various, according to the quality of the metal, and the temper it has received. The harder the steel the coarser the grain. But in like circumstances, fine steel has the closest grain, and is ever the most uniform in its appearance. Workmen avail themselves much of this indication. In general a neat curve lined fracture, and even grey texture, denote good steel: and the appearance of threads, cracks, or brilliant specks, denotes the contrary. But the management of the forging and other circumstances of manufacturing will modify these indications; and the steel that is good for some purposes, may be less suited to others.

It is found, that steel is more effectually hardened in cold than in warm water, and at like temperatures more effectually in mercury than in water. Oil is found to harden the surface of steel much more than its internal part, so that it resists the file, but is much less easily broken by the hammer. Tallow differs from oil in the heat which becomes latent for its fusion; and accordingly, solid tallow is an excellent material for hardening drills and other small articles. The makers of files cover them with the grounds of beer and common salt, which assist their hardening, and keep the surface from scorifying. The mucilage of the beer supplies a coally matter; and the fused salt forms a varnish in the fire, and defends the steel. Very small articles heated in a candle are found to be hardened perfectly by suddenly whirling them in the cold air; and thin bars or plates of steel, such as the magnetic needle of a compass, acquire a good degree of hardness by being ignited, then laid on a plate of cold lead, and suddenly covered with another plate. These would be unequally hardened, and bend, if plunged in water.

The black spot which remains upon steel, or crude iron, after its surface has been corroded by acids, consists of plumbago, which remains after the iron has disappeared by solution.

Solution in the sulphuric or muriatic acid not only exhibits the plumbago contained in iron, but likewise possesses the advantage of showing the state of its reduction by the quantity of hydrogen gas which is disengaged: for the quantity of this gas, in like circumstances, is proportional to that of the iron which is converted into oxide. It is found, that the white crude iron affords the least quantity of hydrogen in proportion to its bulk, and leaves a moderate portion of plumbago; the grey crude iron affords more hydrogen, and more plumbago, than the white; and the softest bar iron affords most hydrogen of any, and little or no plumbago. The quantities of hydrogen gas, at a medium, by ounce measures, were 62, afforded by 100 grains of the white crude iron; 71 by the grey crude iron; and 77 by the malleable iron.

Iron is one of the principal ingredients for dyeing black. The stuff is first prepared with a bath of galls and logwood, then with a similar bath to which verdigris is added, and lastly dyed in a similar bath, with the addition of sulphate of iron. If it be wished that the colour should be particularly fine, the stuff should previously be dyed of a deep blue: otherwise a brown may be first given with the green husks of walnuts. Silk however must not be previously blued with indigo, and sumach may be substituted instead of galls. Leather, prepared by tanning with oak bark, is blackened by a solution of sulphate of iron.

Cotton has a very strong affinity for oxide of iron, so that if it be immersed in a solution of any salt of iron, it assumes a chamois colour, more or less deep according to the strength of the solution. The action of the air on the oxide of iron deepens the colour; and if the shade were at first deep, the texture of the stuff is liable to be corroded by it. To prevent this, the cotton should be immersed in the solution cold, carefully wrung, and immediately plunged into a ley of potash mixed with a solution of alum. After having lain in this four or five hours, it is to be wrung, washed, and dried.

In order to prevent gun-barrels from rusting, they are frequently browned. This is done by rubbing them over when finished with aquafortis or spirit of salt diluted with water, and laying them by for a week or two till a complete coat of rust is formed. A little oil is then applied, and the surface, being rubbed dry, is polished by means of a hard brush and a little bees' wax.

The yellow spots called iron-moulds, which are frequently occasioned by washing ink spots with soap, may in general be removed by lemon-juice, or the oxalic or citric acids; or by muriatic acid diluted with five or six parts of water, but this must be washed off in a minute or two. Ink spots may readily be removed by the same means. If the iron mould have remained so long that the iron is very highly oxidized, so as to be insoluble in the acid, a solution of an alkaline sulphuret may be applied; and after this has been well washed off, the acid will remove the stain.

To the preceding details, which are selected from Mr. Nicholson's work, I shall subjoin a short systematic view of the chemical nature and relations of iron.

I. *Of pure iron.*

Its specific gravity is 7.7, but it may be made 7.8 by hammering. Under the article COHESION, the tenacity of iron is given in reference to other solids. In malleability it is much inferior to gold, silver, and copper; though in ductility it approaches these metals; for iron wires of 1-150th of an inch are frequently drawn. Its melting point is estimated by Sir G. Mackenzie at 158° Wedgewood; the extreme heat of our chemical furnaces.

Dr Wollaston first showed, that the forms in which native iron is disposed to break, are those of the regular octohedron and tetrahedron, or rhomboid, consisting of these forms combined. In a specimen possessed by this philosopher, the crystalline surfaces appear to have been the result of a process of oxidation which has penetrated the mass to a considerable depth in the direction of its laminæ; but in the specimen which is in the possession of the Geological Society, the brilliant surfaces that have been occasioned by forcible separation from the original mass, exhibit also the same configurations as are usual in the fracture of octohedral crystals, and are found in many simple metals. This spontaneous decomposition of the metal in the direction of its crystalline laminæ is a new and valuable fact.

From Mr. Daniell's ingenious experiments on the mechanical structure of iron, developed by solution, we learn, that a mass of *bar iron* which had undergone all the operations of *puddling* and *rolling*, after being left in liquid muriatic acid, till saturation, presented the appearance of a bundle of fasces, whose fibres run parallel through its whole length. At its two ends, the points were perfectly detached from each other, and the rods were altogether so distinct, as to appear to the eye to be but loosely compacted.

II. *Compounds of iron.*

1. Oxides; of which there are three, probably four.

1*st*, The oxide, obtained either by digesting an excess of iron filings in water, by the combustion of iron wire in oxygen, or by adding pure ammonia to solution of green copperas, and drying the precipitate out of contact of air, is of a black colour, becoming white by its union with water, in the hydrate, attractible by the magnet, but more feebly than iron. By a mean of the experiments of several chemists, its composition seems to be,

Iron,	100	77.82	3.5
Oxygen,	28.5	22.18	1.0

Whence the prime equivalent of iron comes out, we perceive, 3.5. Sir H. Davy's number, reduced to the oxygen scale, is 6.86, one-half of which, 3.43, is very nearly the determination of Berzelius.

M. Thenard in his Traité, vol. ii. p. 73, says, the above oxide, obtained by decomposing protosulphate of iron by potash or soda, and washing the precipitate in close vessels with water deprived of its air, consists, according to M. Gay Lussac, of 100 parts of iron, and 25 of oxygen. This determination would make the atom of iron 4.0; and is probably incorrect. This proportion is proved, he adds, by dissolving a certain quantity of iron in dilute sulphuric acid, and collecting the evolved hydrogen. Now, by this method, extreme precision should be ensured.

2*d*, Deutoxide of M. Gay Lussac. He forms it by exposing a coil of fine iron wire, placed in an ignited porcelain tube, to a current of steam, as long as any hydrogen comes over. There is no danger, he says, of generating peroxide in this experiment, because iron once in the state of deutoxide has no such affinity for oxygen as to enable it to decompose water. It may also, he states, be procured by calcining strongly a mixture of 1 part of iron and 3 parts of the red oxide in a stone-ware crucible, to the neck of which a tube is adapted to cut off the contact of air. But this process is less certain than the first, because a portion of peroxide may escape the reaction of the iron. But we may dispense with the trouble of making it, adds M. Thenard, because it is found abundantly in nature. He refers to this oxide, the crystallized specular iron ore of Elba, Corsica, Dalecarlia, and Sweden. He also classes under this oxide all the magnetic iron ores; and says, that the above described protoxide does not exist in nature. From the synthesis of this oxide by steam, M. Gay Lussac has determined its composition to be,

Iron,	100	72.72
Oxygen,	37.5	27.28

3*d*, Hitherto the oxide in the scales of iron, found at the smiths' anvil, has been regarded as identical with the native magnetic oxide, and that obtained by transmitting steam over ignited iron wire. But M. Berthier, in the course of some recent experiments, has found reason to conclude, that these scales do not contain so much oxygen as the deutoxide of Gay Lussac. This oxide, intermediate between the protoxide and the magnetic oxide, does not form a peculiar order of salts; it is decomposed by the action of acids into protoxide and peroxide, just as the deutoxide of Gay Lussac, and this property affords an easy means of analyzing it. In this way he determined its constitution to be two atoms of protoxide and one of peroxide; or in weight,

Protoxide,	64.2	or, Iron,	74.5	100
Peroxide,	35.8	Oxygen,	25.5	34.4
	100.0			

Hence a fourth oxide must be admitted; and in these four, says M. Berthier, the quantities of oxygen combined with the same quantity of iron will be to each other as the numbers 6, 7, 8, 9. The scales of iron oxide that yield on analysis less than 35 per cent. of peroxide, are not pure, but contain a mixture of *scoriæ*, evinced by the jelly which they form with acids. The density of these scales is about 3.5; whence he infers that they cannot be composed of deutoxide and metallic iron; that of the former being 4.7, and of the latter 7.5. *Ann. de Chim.* xxvii. 19.

4*th*, The red oxide. It may be obtained by igniting the nitrate, or carbonate; by calcining iron in open vessels; or simply by treating the metal with strong nitric acid, then washing and drying the residuum. Colcothar of vitriol, or thoroughly calcined copperas, may be considered as peroxide of iron. It exists abundantly native in the red iron ores. It seems to be a compound of

Iron,	100
Oxygen,	43

2. Chlorides of iron; of which there are two, first examined in detail by Dr. John Davy.

The protochloride may be procured by heating to redness, in a glass tube with a very small orifice, the residue which is obtained by evaporating to dryness the green muriate of iron. It is a fixed substance, requiring a red heat for its fusion. It has a greyish variegated colour, a metallic splendour, and a lamellar texture. It absorbs chlorine when heated in this gas, and becomes entirely converted into the volatile deutochloride. It consists, by Dr. Davy, of

Iron,	46.57
Chlorine,	53.43

The deutochloride may be formed by the combustion of iron wire in chlorine gas, or by gently heating the green muriate in a glass tube. It is the volatile compound described by Sir H. Davy in his celebrated Bakerian lecture on oxymuriatic acid. It condenses after sublimation, in the form of small brilliant iridescent plates.

It consists, by Dr. Davy, of iron, 35.1
chlorine, 64.9

3. For the *iodide* of iron, see Iodine.

4. Sulphurets of iron; of which only two are usually described, the protosulphuret and persulphuret.

Dr. Hare, of Philadelphia, says, that if a gun-barrel is heated red at the butt end, and a piece of sulphur thrown into it, then either blowing through the barrel, or closing the mouth with a cork, will produce a jet of sulphurous vapour at the touch-hole, to which, if iron wire be exposed, it will burn, as if ignited in oxygen gas, and fall in fused globules of protosulphuret of iron.

The persulphuret of iron exists in nature. It has the metallic appearance of bronze, but its powder is blackish-grey. It is in fact the magnetic pyrites of mineralogy, which see among the Ores of iron. By the analysis of Mr. Hatchett and Professor Proust, it seems to consist of iron, 63
sulphur. 37

The persulphuret is the cubic iron pyrites of the mineralogist.

The mean of Mr. Hatchett's celebrated experiments on pyrites, published in the Phil. Trans. for 1804, gives of iron, 100
sulphur, 113

5. Carburets of iron. These compounds form steel, and probably cast-iron; though the latter contains also some other ingredients. The latest practical researches on the constitution of these carburets are those of Mr. Daniell, M. Berzelius, and M. Karsten. For the last, see the *Annales des Mines*, ix. 657.

A mass of steel just taken from the crucible in which it had been fused was subjected to the action of muriatic acid. It was of a radiated texture. When withdrawn from the solvent, it presented a highly crystalline arrangement, composed of minute brilliant plates. A bar of steel of an even granular fracture being broken into two, the pieces were heated in a furnace to a cherry red. In this state one of them was plunged into cold water, and the other allowed to cool gradually by the slow extinction of the fire. They were then both placed in muriatic acid, to which a few drops of nitric acid had been added. The softened piece of steel was readily attacked; but it required a period five times greater to saturate the acid with the hard piece. When the solvent had ceased to act on both, they were examined. The hard steel was exceedingly brittle, its surface was covered with small cavities like worm-eaten wood, but its texture was very compact, and not at all striated. The other piece was inelastic and flexible, and presented a fibrous and wavy texture. On this texture the excellence of iron for mechanical purposes is known to depend; and the parts not fibrous are thrown off by the processes of puddling and hammering. By cutting the iron bars into short pieces repeatedly, tying them in bundles, and welding them together, a similar interlacement of fibres is given to this valuable metal, as to flax and hemp, by carding and spinning. May not the superior quality of the Damascus sword blades, which is still a problem, says Mr. Daniell, to our manufacturers, be owing to some such management? A specimen of *white cast-iron*, of a radiated fracture, took just three times as long to saturate a given portion of acid, as a cube of *grey cast-iron*, or a mass of *bar-iron*. Its texture, after this action, appeared to be composed of a congeries of plates, aggregated in various positions, sometimes producing stars upon the surface, from the intersection of their edges. A small bar of *cold short iron*, exceedingly brittle, and presenting in its fracture bright and polished surfaces, resembling antimony, after the action of the acid, proved to be fibrous. A rod of *hot short-iron* presented, at the end of the operation, a closely compacted mass of very small fibres, perfectly continuous. The congeries was twisted, but the threads preserved their parallelism.

In decomposing by heat alone several of the ferroprussiates, M. Berzelius found residuums in the retorts, which were atomic compounds of carbon and iron. These he named carburets, bicarburets, tricarburets, and quadricarburets, the last being the most frequent combination. As his equivalent number for iron is nearly the double of that adopted above, his quadricarburet will be a compound of carbon 3. + iron 7; or it will be our bicarburet, carbon 1.5 + iron 3.5.—*Ann. de Chim. et Phys.* xv. 144, or *Annals of Phil. N. S.* i. 446.

MM. Berzelius and Stromeyer produced a compound, which they consider as a combination of iron, carbon, and silicium, the unknown basis of silica. They mixed into a paste with gum or linseed oil very pure iron, silex, and charcoal, and heated the mixture very intensely in a covered crucible. They inferred, that silicium, in the metallic or inflammable state, existed in the product, because the sum of the iron and silex extracted from the alloy, very sensibly exceeded the total weight of the alloy; because the alloy gave a much greater quantity of hydrogen, with muriatic acid, than the iron alone which it contained would have afforded; and because there is no known combination of a metal with an earth, which requires the successive operation of the most powerful agents to decompose it, as this alloy did. The colour of this compound was that of common steel.

The quantities of the component parts, however, of this alloy, differed very materially from those of the purified carburet obtained from cast-iron. The former varied from the proportions of

Iron,	85.3 to	96.1
Silicium,	9.2	2.2
Carbon,	5.3	1.6

The artificial compound was highly magnetical, while the triple carburet is not. Mr. Daniell, in examining by solution in acid a cube of grey cast-iron, obtained a porous spongy substance, untouched by the menstruum. It was easily cut off by a knife; had a dark grey colour somewhat resembling plumbago, and when placed in considerable quantity on blotting paper to dry, it spontaneously heated, ignited, and scorched the paper. Its properties were not impaired by being left for weeks in the solution of iron, or in water. After a series of elaborate analytical experiments, Mr. Daniell infers the composition of this cast-iron to be,

Iron,	84.66		
Foreign matter,	15.34	silex,	10.43
		double carbur.	4.91
			15.34

And 100 grains of the double carburet of iron and silex, upon an average of 5 experiments, gave the following results:

Red oxide of iron,	31.2	= 28.0	black oxide
Silex,	22.3	= 20.6	oxide of silicium?
Carbon,	51.4	= 51.4	
	104.9	100.0	

Although the existence of silicium in the metallic state alloyed with iron is not actually demonstrated by the preceding experiments, yet it is rendered extremely probable. But, as Mr. Daniell remarks, much remains to be done to complete our knowledge of the nature of cast-iron.

The composition of steel is also very variable. According to M. Vauquelin, the carbon forms 1/140 part, on an average. By enclosing diamonds in cavities of soft iron, and igniting, the former disappeared, and the inner surface of the latter was converted into steel. M. Clouet makes the carbon in cast-iron = 1/4 of the whole weight. But Berzelius makes the latter species a very complex compound. A specimen of very pure cast-iron analysed by him, yielded,

Iron,	90.80
Silicium,	0.50
Magnesium,	0.20
Manganese,	4.57
Carbon,	3.90
	100.00

Mr. Mushet has inserted in several volumes of the Phil. Magazine, many excellent papers on the manufacture and habitudes of iron. In the 5th volume of the Manchester Memoirs, a good account of the process used at Sheffield for converting cast-iron into pure iron, and pure iron into steel, has been published by Mr. Joseph Collier. He has given a drawing of the steel furnace of cementation. I regret that the limits of this work prevent me from transcribing their valuable communications. I shall merely annex Mr. Mushet's table of the proportions of carbon corresponding to different carburets of iron.

1/120	Soft cast steel.
1/100	Common cast steel
1/90	The same, but harder.
1/50	The same too hard for drawing.
1/25	White cast-iron.
1/20	Mottled cast-iron.
1/15	Black cast-iron.

Graphite or plumbago is also a carburet of iron, containing about 10 per cent. of metal, which, calling the prime of iron 1.75, makes it a compound of 21 primes of carbon to 1 of metal.

Pure iron becomes instantly magnetic when presented to a magnetic bar; and as speedily loses its magnetism when the bar is withdrawn. Its coercive power, in resisting the decomposition or recomposition of the austral and boreal magnetisms, is extremely feeble. But when iron is combined with oxygen, carbon, sulphur, or phosphorus, it acquires the magneto-coercive virtue, which attains a maximum of force, with certain proportions of the constituents, hitherto undetermined. Mr. Hatchett is the only chemist who has adverted to this subject in a philosophical manner.—"Speaking generally of the carburets, sulphurets, and phosphurets of iron, I have no doubt," says

The most useful alloy of iron is that with tin, in tin-plate. The surface of the iron plates is cleaned first, by steeping in a crude bran-vinegar, and then in dilute sulphuric acid; after which they are scoured bright with hemp and sand, and deposited in pure water, to prevent oxidation. Into a pot, containing equal parts of grain and block-tin in a state of fusion, covered with tallow, the iron plates are immersed in a vertical direction, having been previously kept for about an hour in melted tallow. From 300 to 400 plates are tinned at a time: each parcel requires an hour and a half for mutual incorporation of the metals. After lifting out the tinned plates, the striæ are removed from their surfaces, and under edges, by subsequent immersion in melted tin, and then in melted tallow, wiping the surfaces at the same time with a hempen brush.

Very curious and instructive experiments on the alloys of steel with several metals, with a view to improve cutting instruments and reflecting mirrors, have been lately made in the laboratory of the Royal Institution, of which an account is inserted in the 18th number of the Journal of Science.

Alloys of steel with platinum, rhodium, gold, and nickel, may be obtained when the heat is sufficiently high. This is so remarkable with platinum, that it will fuse when in contact with steel, at a heat at which the steel itself is not affected.

There are some very curious circumstances attending the alloy of silver. If steel and silver be kept in fusion together for a length of time, an alloy is obtained, which appears to be very perfect while the metals are in the fluid state, but on solidifying and cooling, globules of pure silver are expressed from the mass, and appear on the surface of the button. If an alloy of this kind be forged into a bar, and then dissected, by the action of dilute sulphuric acid, the silver appears not in combination with the steel, but in threads throughout the mass: so that the whole has the appearance of a bundle of fibres of silver and steel, as if they had been united by welding. The appearance of these silver fibres is very beautiful; they are sometimes one-eighth of an inch in length, and suggest the idea of giving mechanical toughness to steel, where a very perfect edge may not be required. The most interesting result is the following:—When 1 of silver and 500 steel were properly fused together, a very perfect button was produced; no silver appeared on its surface; when forged, and dissected by an acid, no fibres were seen, although examined by a high magnifying power. The specimen forged remarkably well, although very hard; it had, in

portion of silver. It has been repeatedly made, and always with success. Various cutting tools have been made from it of the best quality. Mr. Stodart, a very eminent cutler, assisted at these experiments, which must give the public confidence in their practical results.

Equal parts, by weight, of platinum and steel, form a beautiful alloy, which takes a fine polish, and does not tarnish; the colour is the finest imaginable for a mirror. The sp. gr. of this beautiful compound is 9.862. The proportions of platinum that appear to improve steel for edge instruments are from 1 to 3 per cent. While an alloy of 10 platinum with 80 steel, after lying many months exposed, had not a speck on its surface, an alloy of 10 nickel with 80 platinum was in the same circumstances covered with rust.

The alloys of steel with rhodium would prove highly valuable, were it not for the scarcity of the latter metal.

Messrs. Stodart and Faraday, in a new memoir on these alloys, published in the Phil. Trans. for 1822, part ii., observe, that when pure iron is substituted for steel, the alloys so formed are much less subject to oxidation: 3 per cent. of iridium and osmium, fused with pure iron, gave a button, which, when forged and polished, was exposed with many other pieces of iron, steel, and alloys, to a moist atmosphere: it was the last of all in showing any rust. The colour of this compound was distinctly blue; it had the property of becoming harder when heated to redness, and quenched in a cold fluid. On observing this steel-like character, they suspected the presence of carbon; none however was found, although it was carefully looked for. It is not improbable that there may be other bodies besides charcoal, capable of giving to iron the properties of steel; and though they cannot agree with M. Boussingault, when he would replace carbon in steel, by silica or its base, they think his experiments very interesting on this point, which is worthy of farther examination. The editor of the Journal of Science, in commenting on the above alloys, considers, that "a bar of the best ordinary steel, selected with precaution, and most carefully forged, wrought, and tempered, *under the immediate inspection of the master*, would afford cutting instruments as perfect and excellent as those composed of wootz or of the alloys."—*Journal*, xiv. 378.

There is a species of steel made in India, called *wootz*, possessed of excellent qualities, which seems to have been successfully imitated in these late experiments at the Royal Institution. In a previous number of the same Journal, (14th), Mr. Faraday had detailed a minute, and, apparently, a very accurate analysis operated on a part of one of the cakes of wootz, presented by the Right Hon. Sir Joseph Bankes to Mr. Stodart. 460 grains gave 0·3 of a grain of silex, 0·6 of a grain of alumina. 420 grains of the best English steel, furnished by Mr. Stodart, afforded no earths whatever. The imitative synthesis was performed in the following way:—

Pure steel in small pieces, and, in some instances, good iron, being mixed with charcoal powder, were intensely heated for a long time. Thus, carburets, having a dark-green metallic colour, were formed highly crystallized, resembling somewhat the black ore of tellurium. When broken, the facets of small buttons, not weighing more than 500 grains, were frequently above the eighth of an inch in width. The results of several experiments on its composition, which appeared very uniform, gave 94·36 iron + 5·64 carbon. This being broken and rubbed to powder in a mortar, was mixed with pure alumina, and the whole intensely heated in a close crucible for a considerable time. On being removed from the furnace and opened, an alloy was obtained of a white colour, a close granular texture, and very brittle. This, when analyzed, gave 6.4 per cent. of alumina, and a portion of carbon not accurately estimated. 700 of good steel, with 40 of the alumina alloy, were fused together, and formed a very good button perfectly malleable. This, on being forged into a little bar, and the surface polished, gave, on the application of sulphuric acid, the beautiful damask peculiar to wootz. A second experiment was made with 500 grains of the same steel, and 67 of the alumina alloy, which also proved good. It forged well, and gave the damask. This specimen had all the appreciable characters of the best Bombay wootz. It is highly probable, that the much admired sabres of Damascus are made from this steel; and if this be admitted, there can be little reason to doubt, that the damask itself is merely an exhibition of crystallization. Wootz requires for tempering to be heated fully 40° F. above the best English cast steel; and affords a finer and more durable edge.

When soft steel is ignited to a cherry-red, and suddenly plunged in cold water, it is rendered so hard as to resist the file, and nearly as brittle as glass. The tempering of steel consists in reducing this excessive hardness to a moderate degree, by a gentle heating, which also restores its toughness and elasticity. In the year 1789, Mr. Hartley obtained a patent for a mode of tempering cutting instruments of steel, by immersion in oil, heated to a regulated temperature, measured by a thermometer. This was certainly a great improvement, both in point of precision and despatch, on the common method of heating the instrument over a flame, till a certain colour, produced by a film of oxide, appears on its surface. These colours are,

At 430° F.	a very faint yellow, for lancets.
450	a pale straw-colour for razors and surgeons' instruments.
470	a full yellow for penknives.
490	a brown colour, for scissars and chissels for cutting old iron.
510	a brown, with purple spots, for axes and plane-irons.
530	a purple, for table-knives and large shears.
550	a bright blue, for swords, watch-springs, truss-springs, and bell-springs.
560	a full-blue, for small fine saws, daggers, &c.
600	dark-blue, verging on black, is the softest of all the gradations, when the metal becomes fit only for hand and pit-saws, which must be soft, that their teeth may bear sharpening by the file, and setting by the hammer, or pliers.

If the steel be heated still further, it becomes perfectly soft. When tools having a thick back and thin edge, like penknives, are to be tempered, they are placed with their backs on a plate of hot iron or on hot sand; otherwise they would become too soft at the edge, before the backs would be sufficiently heated. To prevent warping of long blades, or bars for magnets, they are generally hardened by being plunged vertically into water. It is evident, that melted pewter, covered with grease, may be used instead of hot oil for tempering steel; the heat being regulated by a thermometer.

"Some recent experiments, proving that steel for certain uses is sufficiently tempered long before it is heated to produce any change of colour, promise to give additional value to this process by a thermometer. The knife-edges attached to the pendulum described by Captain Kater (Phil. Trans. 1818, p. 38), were forged by Mr. Stodart, from a piece of fine wootz. They were carefully hardened and tempered in the bath at 430°; on trial they were found too soft. They were a second time hardened, and then heated to 212° F. The intention was to increase the heat from that point, trying the temper at the advance of about every ten degrees. In the present instance, this was not necessary, the heat of boiling water proving to be the exact point at which the knife edges were admirably tempered. It is highly probable that steel, for many uses, may be sufficiently tempered in a range so extensive as from 212° to 230°; and by the thermometer, all the intervening degrees may certainly be ascertained."—*Brande's Manual*, ii. 132.

III. *Salts of iron.*

These salts have the following general characters:—

1. Most of them are soluble in water; those with the protoxide for a base are gene-

rally crystallizable; those with the peroxide are generally not; the former are insoluble, the latter soluble in alcohol.

2. Ferroprussiate of potash throws down a blue precipitate, or one becoming blue in the air.

3. Infusion of galls gives a dark purple precipitate, or one becoming so in the air.

4. Hydrosulphuret of potash or ammonia gives a black precipitate; but sulphuretted hydrogen merely deprives the solutions of iron of their yellow-brown colour.

5. Phosphate of soda gives a whitish precipitate.

6. Benzoate of ammonia, yellow.

7. Succinate of ammonia, flesh-coloured with the peroxide.

1. *Protacetate of iron* forms small prismatic crystals, of a green colour, a sweetish styptic taste, and a sp. gr. 1·368.

2. *Peracetate of iron* forms a reddish-brown uncrystallizable solution, much used by the calico-printers, and prepared by keeping iron turnings, or pieces of old iron, for six months immersed in redistilled pyrolignous acid. See ACID (ACETIC).

3. *Protarseniate of iron* exists native in crystals, and may be formed in a pulverulent state, by pouring arseniate of ammonia into sulphate of iron. It is insoluble, and consists, according to Chenevix, of 38 acid, 43 oxide, and 19 water, in 100 parts.

4. *Perarseniate of iron* may be formed by pouring arseniate of ammonia into peracetate of iron; or by boiling nitric acid on the protarseniate. It is insoluble.

5. *Antimoniate of iron* is white, becoming yellow, insoluble.

6. *Borate*, pale yellow, insoluble.
7. *Benzoate*, yellow, insoluble.
8. *Protocarbonate*, greenish, soluble.
9. *Percarbonate*, brown, insoluble.
10. *Chromate*, blackish, do.
11. *Protocitrate*, brown crystals, soluble.
12. *Protoferroprussiate*, white, insoluble.
13. *Perferroprussiate*, blue, do.

This constitutes the beautiful pigment called prussian blue. When exposed to a heat of about 400°, it takes fire in the open air; but in close vessels it is decomposed, apparently, into carburetted hydrogen, water, and hydrocyanate of ammonia, which come over; while a mixture of charcoal and oxide of iron remains in the state of pulverulent pyrophorus, ready to become inflamed with contact of air. I have already considered the constitution of prussian blue, in treating of the ACID (FERROPRUSSIC); and have little farther to add to what is there stated.

When sulphuric acid is added to prussian blue, it makes it perfectly white, apparently by abstracting its water; for the blue colour returns on dilution of the acid, and if the strong acid be poured off, it yields no traces of either prussic acid or iron. On submitting pure prussian blue for some time to the action of sulphuretted hydrogen water, small brilliant crystals of a yellowish colour appeared, which became blue in the air, and were protoprussiate of iron.

14. *Protogallate*, colourless, soluble.
15. *Pergallate*, purple, insoluble.
16. *Protomuriate*, green crystals, very soluble.
17. *Permuriate*, brown, uncrystallizable, very soluble. See the *chlorides of iron* previously described.
18. *Protonitrate*, pale green, soluble.
19. *Pernitrate*, brown, do.
20. *Protoxalate*, green prisms, do.
21. *Peroxalate*, yellow, scarcely soluble.
22. *Protophosphate*, blue, insoluble.
23. *Perphosphate*, white, do.
24. *Protosuccinate*, brown crystals, soluble.
25. *Persuccinate*, brownish-red, insoluble.
26. *Protosulphate*, green vitriol, or copperas. It is generally formed by exposing native pyrites to air and moisture, when the sulphur and iron both absorb oxygen, and form the salt. There is, however, an excess of sulphuric acid, which must be saturated by digesting the lixivium of the decomposed pyrites with a quantity of iron plates or turnings.

It forms beautiful green crystals, which are transparent rhomboidal prisms, whose faces are rhombs with angles of 79° 50′ and 100° 10′, inclined to each other at angles of 98° 37′ and 81° 23′. Sp. gr. 1·84. Its taste is harsh and styptic. It reddens vegetable blues. Two parts of cold and three-fourths of boiling water dissolve it. It does not dissolve in alcohol. Exposure to air converts the surface of the crystals into a red deutosulphate. A moderate heat whitens it, by separating the water of crystallization, and a stronger heat drives off the sulphuric acid. Its constituents are 28·9 acid, 28.3 protoxide, and 45 water, according to Berzelius.

27. *Persulphate.* Of this salt there seems to be four or more varieties, having a ferreous base.

The tartrate and pertartrate of iron may also be formed; or, by digesting cream of tartar with water on iron filings, a triple salt may be obtained, formerly called tartarized tincture of Mars. See SALT.

Iron is one of the most valuable articles of the materia medica. The protoxide acts as a genial stimulant and tonic, in all cases of chronic debility not connected with organic congestion or inflammation. It is peculiarly efficacious in chlorosis. It appears to me that the peroxide and its combinations are almost uniformly irritating, causing heartburn, febrile heat, and quickness of pulse. Many chalybeate mineral waters contain an exceedingly minute quantity of protocarbonate of iron, and yet exercise an astonishing power in recruiting the exhausted frame. I believe their virtue to be derived simply from the metal being oxidized to a minimum, and diffused by the agency of a mild acid through a great body of water, in which state it is rapidly taken up by the lacteals, and speedily imparts a ruddy hue to the wan countenance. I find that these qualities may be imitated exactly, by dissolving 3 grains of sulphate of iron, and 61 of bicarbonate of potash, in a quart of cool water, with agitation in a close vessel.

IRON-FLINT. Eeisenkiesel.—*Werner*. Colours brown and red. Massive and crystallized in small equiangular six-sided prisms, acuminated on both extremities. It occurs commonly in small angulo-granular distinct concretions. Lustre vitreo-resinous. Fracture small conchoidal. Opaque. Gives sparks with steel. Rather difficultly frangible. Sp. gr. 2.6 to 2.8. Infusible. Its constituents are, 93.5 silica, 5 oxide of iron, and 1 volatile matter. The red iron-flint contains 21.7 oxide of iron, and 76.8 silica. It occurs in veins in ironstone, and in trap-rocks, near Bristol, in the island of Rathlin, at Dunbar, and in many parts of Germany.—*Jameson*.

IRON-ORE. See ORES of iron.

ISATIS TINCTORIA. The plant used for dyeing, called *woad*.

ISERINE. Colour iron-black. In small obtuse angular grains. Lustre splendent or glistening, and metallic. Fracture conchoidal. Opaque. Harder than felspar. Brittle. Retains its colour in the streak. Sp. gr. 4·6. It melts into a blackish-brown glass, which is slightly attracted by the magnet. The mineral acids have no effect on it, but oxalic acid extracts a portion of the titanium. Its constituents are, 48 oxide of titanium, 48 oxide of iron, and 4 uranium, by Dr. Thomson's analysis of the iserine found in the bed of the river Don, in Aberdeenshire; but, by Klaproth, it consists of 28 oxide of titanium, and 72 oxide of iron. On the continent it has hitherto been found only in the lofty Riesengebirge, near the origin of the stream called the Iser, disseminated in granite sand; and in alluvial soil along with pyrope in Bohemia.—*Jameson*.

ISINGLASS. This substance is almost wholly gelatin; 100 grains of good dry isinglass containing rather more than 98 of matter soluble in water.

Isinglass is made from certain fish found in the Danube, and the rivers of Muscovy. Willoughby and others inform us that it is made of the sound of the beluga; and Neumann that it is made of the huso Germanorum, and other fish, which he has frequently seen sold in the public markets of Vienna. Mr. Jackson remarks, that the sounds of cod, properly prepared, afford this substance; and that the lakes of America abound with fish from which the very finest sort may be obtained.

Isinglass receives its different shapes in the following manner:—

The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy *sordes*, divested of a very thin membrane which envelopes the sound, and then exposed to stiffen a little in the air. In this state they are formed into rolls about the thickness of a finger, and in length according to the intended size of the staple: a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards.

Isinglass is best made in the summer, as frost gives it a disagreeable colour, deprives it of weight, and impairs its gelatinous principles.

Isinglass boiled in milk forms a mild nutritious jelly, and is thus sometimes employed medicinally. This, when flavoured by the art of the cook, is the blanc-manger of our tables. A solution of isinglass in water, with a very small proportion of some balsam, spread on black silk, is the court-plaster of the shops.

IVORY. The tusk, or tooth of defence of the male elephant. It is an intermediate substance between bone and horn, not capable of being softened by fire, not altogether so hard and brittle as bone. Sometimes it grows to an enormous size, so as to weigh near two hundred pounds.

The entire tooth is of a yellowish, brownish, and sometimes a dark brown colour on the outside, internally white, hollow towards the root, and so far as was inserted into the jaw, of a blackish-brown colour. The finest, whitest, smoothest, and most compact ivory comes from the island of Ceylon. The grand consumption of this commodity is for making ornamental utensils, mathematical instruments, cases, boxes, balls, combs, dice, and an infinity of toys. The workmen have methods also of tingeing it of a variety of colours.

Merat Guillot obtained from 100 parts of ivory, 24 gelatin, 64 phosphate of lime, and 0.1 carbonate of lime.

The coal of ivory is used in the arts under the denomination of ivory black. Particular vessels are used in the manufactory of this pigment, for the purpose of rendering it perfectly black.

Some travellers speak of the tooth of the sea-horse as an excellent ivory; but it is too hard to be sawed or wrought like ivory. It is used for making artificial teeth.

K

KALI. See Potash.

KAOLIN. The Chinese name of porcelain clay.

KARPHOLITE. A yellow mineral, which occurs in thin prismatic concretions. Specific gravity, 2.935.

KEDRIA TERRESTRIS. Barbadoes tar. See Bitumen.

KELP. Incinerated sea-weed. See Soda.

KERATE. The third mineral order of Mohs. See Mineralogy.

KERMES (*coccus illicis*, Lin.) is an insect found in many parts of Asia, and the south of Europe.

On account of their figure, they were a long time taken for the seeds of the tree on which they live; whence they were called *grains of kermes*. They also bore the name of vermilion.

To dye spun worsted with kermes, it is first boiled half an hour in water with bran, then two hours in a fresh bath with one-fifth of Roman alum, and one-tenth of tartar, to which *sour water* is commonly added; after which it is taken out, tied up in a linen bag, and carried to a cool place, where it is left some days. To obtain a full colour, as much kermes as equals three-fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the first boiling. As cloth is more dense than wool, either spun or in the fleece, it requires one-fourth less of the salts in the boiling, and of kermes in the bath.

The colour that kermes imparts to wool has much less bloom than the scarlet made with cochineal; whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known.

KERMES MINERAL. See Antimony.

KIFFEKILL. See Meerschaum.

KILLAS. The Cornish miner's name for clayslate.

KILLINITE. A mineral of a light green colour, sometimes tinged brown or yellow. Massive, or with some appearance of prisms. Structure lamellar. Lustre glimmering; translucent; yields to the knife; and is easily frangible. Spec. grav. 2.698. Its constituents are silica 52.49, alumina 24.50, lime, magnesia, and oxide of iron, 0.5, potash 5, oxide of iron 2.49, oxide of manganese 0.75, water 5.—*Dr. Barker*. Before the blowpipe it becomes white, swells, and melts into a white enamel.

It was discovered by Dr. Taylor in granite veins at Killiney, near Dublin. It resembles spodumene so much, that the alkali has been suspected to be lithia, and not potash.

KINATE OF LIME. A salt which forms 7 per cent. of cinchona. See Acid (Kinic).

KINO. A few years ago this was introduced into our shops and medical practice by the name of a *gum*; but Dr. Duncan has shown that it is an extract. It contains also a species of *tannin*, whence it is used as an astringent in diarrhœas.

KLEBSCHIEFER. Adhesive slate.

KNEBELITE. A mineral of a grey colour, spotted with dirty white, red, or brown. Massive. Glistening. Fracture imperfectly conchoidal. Opaque, hard, brittle, and difficultly frangible. Spec. grav. 3.714. Its constituents are silica 32.5, protoxide of iron 32.0, protoxide of manganese 35.—*Dobereiner*.

KOLLYRITE. A white, massive, soft, and light mineral, which feels greasy, and adheres to the tongue. It becomes transparent in water, and falls to pieces. It consists of 14 silica, 45 alumina, and 42 water.—*Klaproth*. It occurs in porphyry in Hungary.

KONIGINE. A mineral in small emerald, or blackish-green, translucent crystals. It resembles *Brochantite*, and is probably a subsulphate of copper.—*M. Levy in Annals of Phil.* xi. 194.

KONITE. See Conite.

KOUMISS. A vinous liquid, which the Tartars make by fermenting mare's milk. Something similar is prepared in Orkney and Shetland.

KOUPHOLITE. A variety of prehnite found near Barèges.

KRAMERIC ACID. See Acid (Krameric).

KUPFER NICKEL. See Nickel.

L

LABDANUM. A resin of a species of cistus in Candia, of a blackish colour. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called *labdanum in tortis*. It is greatly adulterated by the addition of black sand. It has been used in cephalic and stomachic plasters and perfumes.

LABORATORY. A place properly fitted up for the performance of chemical operations.

As chemistry is a science founded entirely on experiment, we cannot hope to understand it well, without making such experiments as verify most of the known fundamental operations, and also such as reasoning, analogy, and the spirit of inquiry, never fail to suggest to those whose taste and suitable talents lead them to this essential part of experimental philosophy. Besides, when a person himself observes, and operates, he must perceive, even in the most common operations, a great variety of small facts, which must necessarily be known, but which are not mentioned either in books or in memoirs, because they are too numerous, and would appear too minute. Lastly, there are many qualities in the several agents, of which no just notion can be given by writing, and which are perfectly well known as soon as they have been once made to strike our senses.

Many people think, that a laboratory level with the ground is most convenient, for the sake of water, pounding, washing, &c. It certainly has these advantages; but it is also subject to very great inconvenience from moisture.

Constant moisture, though not very considerable and sensible in many respects, is a very great inconvenience in a chemical laboratory. In such a place, most saline matters become moist in time, and the inscriptions fall off, or are effaced; the bellows rot; the metals rust; the furnaces moulder, and every thing almost spoils. A laboratory, therefore, is more advantageously placed above than below the ground, that it may be as dry as possible. The air must have free access to it; and it must even be so constructed, that, by means of two or more opposite openings, a current of air may be admitted, to carry off any noxious vapours or dust.

In the laboratory a chimney ought to be constructed, so high that a person may easily stand under it, and as extensive as is possible; that is, from one wall to another. The funnel of this chimney ought to be as high as is possible, and sufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no soot is collected in it; and therefore it need not be so wide as to allow a chimney-sweeper to pass up into it.

Under this chimney may be constructed some brick furnaces, particularly a melting furnace, a furnace for distilling with an alembic, and one or two ovens like those in kitchens. The rest of the space ought to be filled up with stands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. These furnaces are the most convenient, from the facility of disposing them at pleasure; and they are the only furnaces which are necessary in a small laboratory. A double pair of bellows of moderate size must also be placed as commodiously under the chimney, or as near, as the place will allow. These bellows are sometimes mounted in a portable frame; which is sufficiently convenient, when the bellows are not more than eighteen or twenty inches long. These bellows ought to have a pipe directed toward the hearth where the forge is to be placed.

The necessary furnaces are, the simple furnace, for distilling with a copper alembic; a lamp furnace; two reverberatory furnaces of different sizes, for distilling with retorts; an air or melting furnace, an assay furnace, and a forge furnace.

Under the chimney, at a convenient height, must be a row of hooks driven into the back and side walls; upon which are to be hung small shovels; iron pans; tongs; straight, crooked, and circular pincers; pokers; iron rods, and other utensils for disposing the fuel and managing the crucibles.

To the walls of the laboratory ought to be fastened shelves of different breadths and heights; or these shelves may be suspended by hooks. The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible. In a laboratory where many experiments are made, there cannot be too many shelves.

The most convenient place for a stone or leaden cistern, to contain water, is a corner of the laboratory, and under it a sink ought to be placed with a pipe, by which the water poured into it may discharge itself. As the vessels are always cleaned under this cistern, cloths and bottle brushes ought to be hung upon hooks fastened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, solutions, precipitations, small filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory are to be placed blocks of wood upon mats; one of which is to support a middle-sized iron mortar; another to support a middle-sized marble, or rather hard stone mortar; a third to support an anvil. Near the mortars are to be hung searces of different sizes and fineness; and near the anvil a hammer, files, rasps, small pincers, scissars, shears, and other small utensils, necessary to give metals a form proper for the several operations.

Two moveable trestles ought to be in a laboratory, which may serve to support a large filter mounted upon a frame, when it is required. This apparatus is removed occasionally to the most convenient place.

Charcoal is an important article in a laboratory, and it therefore must be placed within reach; but as the black dust which flies about it whenever it is stirred is apt to soil every thing in the laboratory, it had better be in some place near the laboratory, together with some furze, which is very convenient for kindling fires quickly. This place serves, at the same time, for containing bulky things which are not often wanted; such as furnaces, bricks, tiles, clay, fire-clay, quicklime, sand, and many other things necessary for chemical operations.

Lastly, a middle-sized table, with solid feet, ought to be enumerated among the large moveables of a laboratory, the use of which is to support a porphyry, or levigating stone, or rather a very hard and dense grit-stone, together with a muller made of the same kind of stone.

The other small moveables or utensils of a laboratory are, small hand mortars of iron, glass, agate, and Wedgewood's ware, and their pestles; earthen, stone, metal, and glass vessels of different kinds, funnels, and measures.

Some white writing paper, and some unsized paper for filters; a large number of clean straws, eight or ten inches long, for stirring mixtures in glasses, and for supporting paper filters placed in glass funnels.

Glass tubes for stirring and mixing corrosive liquors; spatulas of wood, ivory, metal, and glass.

Thin pasteboards, and horns, very convenient for collecting matters bruised with water upon the levigating stone, or in mortars; corks of all sizes; bladders and linen strips for luting vessels.

A good portable pair of bellows; a good steel for striking fire; a glue-pot, with its little brush; lastly, a great many boxes, of various sizes, for containing most of the above-mentioned things, and which are to be placed upon the shelves.

Besides these things, some substances are so necessary in most chemical operations, that they may be considered as instruments requisite for the practice of this science. These substances are called reagents, which see under ORES (ANALYSIS OF), and WATERS (MINERAL).

All metals, which ought to be very pure.

A person provided with such instruments and substances may at once perform many chemical experiments.

The general observations of Macquer upon the conducting of chemical processes are truly valuable and judicious. Method, order, and cleanliness, are essentially necessary in a chemical laboratory. Every vessel and utensil ought to be well cleansed as often as it is used, and put again into its place; labels ought to be put upon all the substances. These cares, which seem to be trifling, are however very fatiguing and tedious; but they are also very important, though frequently little observed. When a person is keenly engaged, experiments succeed each other quickly; some seem nearly to decide the matter, and others suggest new ideas; he cannot but proceed to them immediately, and he is led from one to another: he thinks he shall easily know again the products of the first experiments, and therefore he does not take time to put them in order; he prosecutes with eagerness the experiments which he has last thought of; and in the mean time, the vessels employed, the glasses and bottles filled, so accumulate, that he cannot any longer distinguish them; or, at least, he is uncertain concerning many of his former products. This evil is increased, if a new series of operations succeed, and occupy all the laboratory; or, if he be obliged to quit it for some time, every thing then goes into confusion. Thence it frequently happens, that he loses the fruits of much labour, and that he must throw away almost all the products of his experiments.

When new researches and inquiries are made, the mixtures, results, and products of all the operations ought to be kept a long time, distinctly labelled and registered; for these things, when kept some time, frequently present phenomena that were not at all suspected. Many fine discoveries in chemistry have been made in this manner; and many have certainly been lost by throwing away too hastily, or neglecting the products.

Since chemistry offers many views for the improvement of many important arts; as it presents prospects of many useful and profitable discoveries; those who apply their labours in this way ought to be exceedingly circumspect, not to be led into an useless expense of money and time. In a certain set of experiments, some one is generally of an imposing appearance, although in reality it is nothing more. Chemistry is full of these half successes, which serve only to deceive the unwary, to multiply the number of trials, and to lead to great expense before the fruitlessness of the search is discovered. By these reflections we do not intend to divert from all such researches, seems to be an advantage to contract the diameter of a chimney, so as to make it smaller than that of the fire-place, when no other air is to go up the chimney than what has passed through the fire; and there is no prospect of advantage to be derived from widening it.

Plate IV. fig. 3. exhibits the wind or air furnace for melting. *a* is the ash-hole, *f* an opening for the air. *c* is the fire-place, containing a covered crucible, standing on a support of baked earth, which rests on the grate; *d* is the passage into *e*, the chimney. At *d* a shallow crucible or cupel may be placed in the current of the flame, and at *x* is an earthen or stone cover, to be occasionally taken off for the purpose of supplying the fire with fuel.

Fig. 2. is a reverberatory furnace. *a a*, the ash-pit and fire-place. *b b*, body of the furnace. *c c*, dome, or reverberating roof of the furnace. *d d*, chimney. *e e*, door of the ash-pit. *f f*, door of the fire-place. *g g*, handles of the body. *h*, aperture to admit the head of the retort. *i i*, handles of the dome. *k*, receiver. *l l*, stand of the receiver. *m m*, retort, represented in the body by dotted lines.

Another reverberatory furnace, a little differing in figure, may be seen in Plate I. fig. 2. *a*.

M. Chenevix has constructed a wind furnace, which is in some respects to be preferred to the usual form. The sides, instead of being perpendicular, are inverted, so that the hollow space is pyramidical. At the bottom the opening is 13 inches square, and at the top but eight. The perpendicular height is 17 inches. This form appears to unite the following advantages:—1st, A great surface is exposed to the air, which, having an easy entrance, rushes through the fuel with great rapidity; 2d, The inclined sides act in some measure as reverberating surfaces; and 3d, The fuel falls of itself, and is always in close contact with the crucible placed near the grate. The late Dr. Kennedy of Edinburgh, whose opinion on this subject claims the greatest weight, found that the strongest heat in our common wind furnaces was within two or three inches of the grate. This, therefore, is the most advantageous position for the crucible, and still more so when we can keep it surrounded with fuel. It is inconvenient and dangerous for the crucible, to stir the fire often to make the fuel fall, and the pyramidical form renders this unnecessary. It is also more easy to avoid a sudden bend in the chimney, by the upper part of the furnace advancing as in this construction. In Plate IV. fig. 1. *a* is a grate; *c* and *c* are two bricks, which can be let in at pleasure to diminish the capacity; *b* is another grate, which can be placed upon the bricks *c* and *c* for smaller purposes; *d* and *d* are bricks which can be placed upon the grate *b* to diminish the upper capacity, so that, in fact, there are four different sizes in the same furnace. The bricks should all be ground down to the slope of the furnace, and fit in with tolerable accuracy. They are totally independent of the pyramidical form of the furnace.

Mr. Aikin's portable blast furnace is composed of three parts, all made out of the common thin black lead melting-pots, sold in London for the use of the goldsmith. The lower piece *c*, fig. 6. is the bottom of one of these pots, cut off so low as only to leave a cavity of about an inch deep, and ground smooth above and below. The outside diameter, over the top, is five inches and a half. The middle piece or fire-place *a*, is a larger portion of a similar pot, with a cavity about six inches deep, and measuring seven inches and a half over the top, outside diameter, and perforated with six blast holes at the bottom. These two pots are all that are essentially necessary to the furnace for most operations; but when it is wished to heap up fuel above the top of a crucible contained, and especially to protect the eyes from the intolerable glare of the fire when in full height, an upper pot *b* is added, of the same dimensions as the middle one, and with a large opening in the side, cut to allow the exit of the smoke and flame. It has also an iron stem, with a wooden handle (an old chisel answers the purpose very well) for removing it occasionally. The bellows, which are double (*d*), are firmly fixed, by a little contrivance which will take off and on, to a heavy stool, as represented in the plate; and their handle should be lengthened so as to make them work easier to the hand. To increase their force, on particular occasions, a plate of lead may be firmly tied on the wood of the upper flap. The nozzle is received into a hole in the pot *c*, which conducts the blast into its cavity. Hence the air passes into the fire-place *a*, through six holes of the size of a large gimlet, drilled at equal distances through the bottom of the pot, and all converging in an inward direction, so that if prolonged, they would meet about the centre of the upper part of the fire. No luting is necessary in using this furnace, so that it may be set up and taken down immediately. Coak, or common cinders, taken from the fire when the coal ceases to blaze, sifted from the dust, and broken into very small pieces, forms the best fuel for higher heats. The fire may be kindled at first by a few lighted cinders, and a small quantity of wood charcoal. The heat which this little furnace will afford is so intense, that its power was at first discovered accidentally by the fusion of a thick piece of cast iron. The utmost heat procured by it was 167° of Wedgewood's pyrometer, when a Hessian crucible was actually sinking down in a state of porcelaneous fusion. A steady heat of 155° or 160° may be depended on, if the fire be properly managed, and the bellows worked with vigour.

The process of cupellation may be exhibited in a lecture, or performed at other times, by means of this furnace. The method consists in causing a portion of the blast to be diverted from the fuel, and to pass through a crucible in which the cupel is placed. This arrangement supplies air; and the whole may be seen by a sloping tube run through the cover of the crucible.

Charcoal is the material most commonly used in furnaces. It produces an intense heat without smoke, but it is consumed very fast. Coak or charred pit-coal produces a very strong and lasting heat. Neither of these produces a strong heat at a distance from the fire. Where the action of flame is required, wood or coal must be burned. Several inconveniencies attend the use of coal, as its fuliginous fumes, and its aptitude to stop the passage of air by becoming fused. It is used, however, in the reverberatory furnaces of glass-houses, and is the best material where vessels are to be supplied with a great quantity of heat at no great intensity, such as in distilleries, &c.

Frequently, however, the flame of an Argand lamp may be employed very conveniently for chemical purposes. Pl. III. fig. 2. is a representation of a lamp furnace, as it is perhaps not very properly called, as improved by Mr. Accum. It consists of a brass rod screwed to a foot of the same metal, loaded with lead. On this rod, which may be unscrewed in the middle for rendering it more portable, slide three brass sockets with straight arms, terminating in brass rings of different diameters. The largest measures four inches and a half. These rings serve for supporting glass alembics, retorts, Florence flasks, evaporating basins, gas bottles, &c.; for performing distillations, digestions, solutions, evaporations, saline fusions, concentrations, analyses with the pneumatic apparatus, &c. If the vessels require not to be exposed to the naked fire, a copper sand bath may be interposed, which is to be previously placed in the ring. By means of a thumbscrew acting on the rod of the lamp, each of the brass rings may be set at different heights, or turned aside, according to the pleasure of the operator. Below these rings is a fountain-lamp on Argand's plan, having a metallic valve within, to prevent the oil from running out while the reservoir is put into its place. This lamp also slides on the main brass rod by means of a socket and thumb-screw. It is therefore easy to bring it nearer, or to move it further, at pleasure, from the vessel, which may remain fixed; a circumstance which, independent of the elevation and depression of the wicks of the lamp, affords the advantage of heating the vessels by degrees after they are duly placed, as well as of augmenting or diminishing the heat instantly; or for maintaining it for several hours at a certain degree, without in the least disturbing the apparatus suspended over it. It may therefore be used for producing the very gentle heat necessary for the rectification of ethers, or the strong heat requisite for distilling mercury. The chief improvement of this lamp consists in its power of affording an intense heat by the addition of a second cylinder, added to that of the common lamp of Argand. This additional cylinder encloses a wick of one inch and a half in diameter, and it is by this ingenious contrivance, which was first suggested by Mr. Webster, that a double flame is caused, and more than three times the heat of an Argand's lamp of the largest size is produced.

Every effect of the most violent heat of furnaces may be produced by the flame of a candle or lamp, urged upon a small particle of any substance, by the blowpipe. This instrument is sold by the ironmongers, and consists merely of a brass pipe about one eighth of an inch diameter at one end, and the other tapering to a much less size, with a very small perforation for the wind to escape. The smaller end is bent on one side. For philosophical or other nice purposes the blowpipe is provided with a bowl or enlargement, *a* (Pl. IV. fig. 5.), in which the vapours of the breath are condensed and detained, and also with three or four small nozzles, *b*, with different apertures, to be slipped on the smaller extremity. These are of use when larger or smaller flames are to be occasionally used, because a larger flame requires a large aperture, in order that the air may effectually urge it upon the matter under examination.

There is an artifice in the blowing through this pipe, which is more difficult to describe than to acquire. The effect intended to be produced is a continual stream of air for many minutes, if necessary, without ceasing. This is done by applying the tongue to the roof of the mouth, so as to interrupt the communication between the mouth and the passage of the nostrils; by which means the operator is at liberty to breathe through the nostrils, at the same time that by the muscles of the lips he forces a continual stream of air from the anterior part of the mouth through the blowpipe. When the mouth begins to be empty, it is replenished by the lungs in an instant, while the tongue is withdrawn from the roof of the mouth, and replaced again in the same manner as in pronouncing the monosyllable *tut*. In this way the stream may be continued for a long time without any fatigue, if the flame be not urged too impetuously, and even in this case no other fatigue is felt than that of the muscles of the lips.

A wax candle, of a moderate size, but thicker wick than they are usually made with, is the most convenient for occasional experiments; but a tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side toward the object, so that a part of it should lie horizontally. The stream of air must be blown along this horizontal part, as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof that the hole is not round and smooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure, and duly proportioned, the flame consists of a neat luminous blue cone, surrounded by another flame of a more faint and indistinct appearance. The strongest heat is at the point of the inner flame.

The body intended to be acted on by the blowpipe ought not to exceed the size of a peppercorn. It may be laid upon a piece of close-grained, well-burned charcoal; unless it be of such a nature as to sink into the pores of this substance, or to have its properties affected by its inflammable quality. Such bodies may be placed in a small spoon made of pure gold, or silver, or platina.

Many advantages may be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation. The most expensive materials, and the minutest specimens of bodies, may be used in these experiments; and the whole process, instead of being carried on in an opaque vessel, is under the eye of the observer from beginning to end. It is true that very little can be determined in this way concerning the quantities of product; but, in most cases, a knowledge of the contents of any substance is a great acquisition, which is thus obtained in a very short time, and will, at all events, serve to show the best and least expensive way of conducting processes with the same matters in the larger way.

The blowpipe has deservedly of late years been considered as an essential instrument in a chemical laboratory; and several attempts have been made to facilitate its use by the addition of bellows, or some other equivalent instruments. These are doubtless very convenient, though they render it less portable for mineralogical researches. It will not, here, be necessary to enter into any description of a pair of double bellows fixed under a table, and communicating with a blowpipe which passes through the table. Smaller bellows, of a portable size for the pocket, have been made for the same purpose. The ingenious chemist will find no great difficulty in adapting a bladder to the blowpipe, which, under the pressure of a board, may produce a constant stream of air, and may be replenished, as it becomes empty, by blowing into it with bellows, or the mouth, at another aperture furnished with a valve opening inwards.

The chief advantage these contrivances have over the common blowpipe is, that they may be filled with oxygen gas, which increases the activity of combustion to an astonishing degree. The vapour from alcohol has likewise been employed, and an ingenious contrivance for this purpose by Mr. Hooke is represented, Pl. IV. fig. 4. *a* is a hollow sphere for containing alcohol, resting upon a shoulder in the ring *o*. If the bottom be made flat instead of spherical, the action of the flame will then be greater. *b* is a bent tube with a jet at the end, to convey the alcohol in the state of vapour into the flame at *q*; this tube is continued in the inside up to *c*, which admits of *a* being filled nearly, without any alcohol running over. *d* is a safety valve, the pressure of which is determined at pleasure, by screwing higher or lower on the pillar *e* the two milled nuts *f* and *g*, carrying the steel arm *h*, which rests on the valve. *i* is an opening for putting in the alcohol. *k* is the lamp, which adjusts to different distances from *a*, by sliding up or down the two pillars *ll*. The distance of the flame *q* from the jet is regulated by the pipe which holds the wick being a little removed from the centre of the brass piece *m*, and of course revolving in a circle. *n* the mahogany stand.

For the various habitudes of bodies when examined by the blowpipe, see Blowpipe.

Little need be said concerning the manner of making experiments with fluid bodies in the common temperature of the atmosphere. Basins, cups, phials, matrasses, and other similar vessels, form the whole apparatus required for the purpose of containing the matters intended to be put together; and no other precaution or instruction is required, than to use a vessel of such materials as shall not be corroded or acted upon by its contents, and of sufficient capacity to admit of any sudden expansion or frothing of the fluid, if expected. This vessel must be placed in a current of air, if noxious fumes arise, in order that these may be blown from the operator.

The method of making experiments with permanently elastic fluids, or gases, though simple, is not so obvious. We live immersed in an atmosphere not greatly differing in density from these fluids, which for this reason are not sufficiently ponderous to be detained in open vessels by their weight. Their remarkable levity, however, affords a method of confining them by means of other denser fluids. Dr. Priestley, whose labours so far exceeded those of his predecessors and contemporaries, both in extent and importance, that he may with justice be styled the father of this important branch of natural philosophy, used the following apparatus.

Pl. III. fig. 1. *a* represents a wooden vessel or tub; *k k k*, is a shelf fixed in the tub. When this apparatus is used, the tub is to be filled with water to such a height, as to rise about one inch above the upper surface of the shelf. *b*, *g*, *f*, are glass jars inverted with their mouths downward, which rest upon the shelf. If these, or any other vessels, open only at one end, be plunged under the water, and inverted after they are filled, they will remain full, notwithstanding their being raised out of the water, provided their mouths be kept immersed; for in this case the water is sustained by the pressure of the atmosphere, in the same manner as the mercury in the barometer. It may, without difficulty, be imagined, that if common air, or any other fluid resembling common air in lightness and elasticity, be suffered to enter these vessels, it will rise to the upper part, and the surface of the water will subside. If a bottle, a cup, or any other vessel, in that state which is usually called empty, though really full of air, be plunged into the water with its mouth downwards, scarce any water will enter, because its entrance is opposed by the elasticity of the included air; but if the vessel be turned up, it immediately fills, and the air rises in one or more bubbles to the surface. Suppose this operation to be performed under one of the jars which are filled with water, the air will ascend as before; but instead of escaping, it will be detained in the upper part of the jar. In this manner, therefore, we see, that air may be emptied out of one vessel into another by an inverted pouring, in which the air is made to ascend from the lower vessel *i* to the upper *g*, in which the experiments are performed, by the action of the weightier fluid, exactly similar to the common pouring of denser fluids detained in the bottoms of open vessels, by the simple action of gravity. When the receiving vessel has a narrow neck, the air may be poured through a glass funnel *h*.

c (*Ibid.*) is a glass body or bottle, the bottom of which is blown very thin, that it may support the heat of a candle suddenly applied, without cracking. In its neck is fitted, by grinding, a tube *d*, curved neatly in the form of the letter *s*. This kind of vessel is very useful in various chemical operations, for which it will be convenient to have them of several sizes. In the figure, the body *c* is represented as containing a fluid, in the act of combining with a substance that gives out air, which passes through the tube into the jar *b*, under the mouth of which the other extremity of the tube is placed. At *e* is a small retort of glass or earthen ware, the neck of which being plunged in the water, beneath the jar *f*, is supposed to emit the elastic fluid, extricated from the contents of the retort, which is received in the jar.

When any thing, as a gallipot, is to be supported at a considerable height within a jar, it is convenient to have such wire-stands as are represented fig. 3. These answer better than any other, because they take up but little room, and are easily bent to any figure or height.

In order to expel air from solid substances by means of heat, a gun-barrel, with the touch-hole screwed up and rivetted, may be used instead of an iron retort. The subject may be placed in the chamber of the barrel, and the rest of the bore may be filled with dry sand, that has been well burned, to expel whatever air it might have contained. The stem of a tobacco-pipe, or a small glass tube, being luted in the orifice of the barrel, the other extremity must be put into the fire, that the heat may expel the air from its contents. This air will of course pass through the tube, and may be received under an inverted vessel, in the usual manner.

But the most accurate method of procuring air from several substances, by means of heat, is to put them, if they will bear it, into phials full of quicksilver, with the mouths inverted in the same, and then throw the focus of a burning lens or mirror upon them. For this purpose, their bottoms should be round and very thin, that they may not be liable to fly with the sudden application of heat. The body *c*, Pl. III. fig. 1. answers this purpose very well.

Many kinds of air combine with water, and therefore require to be treated in an apparatus in which quicksilver is made use of. This fluid being very ponderous and of considerable price, it is an object of convenience, as well as economy, that the trough and vessels should be smaller than when water is used. See Pl. VV. fig. 1. *f f*.

When trial is to be made of any kind of air, whether it be fit for maintaining combustion, the air may be put into a long narrow glass vessel, the mouth of which, being carefully covered, may be turned upward. A bit of wax candle being then fastened to the end of a wire, which is bent so that the flame of the candle may be uppermost, is to be let down into the vessel, which must be kept covered till the instant of plunging the lighted candle into the air.

Where the change of dimensions, which follows from the mixture of several kinds of air, is to be ascertained, a graduated narrow cylindrical vessel may be made use of. The gradations may be made by pouring in successive equal measures of water into this vessel, and marking its surface at each addition. The measure may be afterward used for the different kinds of air, and the change of dimensions will be shown by the rise or fall of the mercury or water in the graduated vessel. The purity of common air being determinable by the diminution produced by the addition of nitric oxide gas, these tubes have been called eudiometer tubes.

Some substances, more especially powders, cannot conveniently be put into a phial, or passed through a fluid. When air is to be extricated from, or added to these, there is no better method, than to place them on a stand under the receiver of the air-pump, and exhaust the common air, instead of excluding it by water or mercury. This process requires a good air-pump, and careful management, otherwise the common air will not be well excluded.

It is frequently an interesting object, to pass the electric spark through different kinds of air, either alone or mixed together. In this case a metallic wire may be fastened in the upper end of a tube, and the sparks or shock may be passed through this wire to the mercury or water used to confine the air. If there be reason to apprehend, that an expansion in the air may remove the mercury or water beyond the striking distance, another wire may be thrust up to receive the electricity; or two wires may be cemented into opposite holes in the sides of an hermetically sealed tube. Holes may be made in glass, for this and other chemical uses, by a drill of copper or soft iron, with emery and water; and where this instrument is wanting, a small round file with water will cut a notch in small vessels, such as phials or tubes, though with some danger of breaking them. In some electrical experiments of the kind here mentioned, there is reason to expect a fallacious result from the wires being burned by the explosion or spark. For this reason, the electricity may be made to pass through the legs of a syphon, containing the air which is under consideration in the upper part of its curvature. One of the vessels, in which the legs of the syphon rest, must therefore be insulated; and if any watery fluid be used to confine the air, it is generally supposed that no combustion takes place.

It is sometimes desirable to impregnate water for medicinal purposes with some gas, as the carbonic acid, and for this the apparatus of Dr. Nooth is very effectual and convenient. It consists of three glass vessels, Pl. III. fig. 4. The lower vessel *c* contains the effervescent materials; it has a small orifice at *d*, stopped with a ground stopper, at which an additional supply of either acid, or water, or chalk, may be occasionally introduced. The middle vessel *b* is open, both above and below. Its inferior neck is fitted, by grinding, into the neck *h* of the lower vessel. In the former is a glass valve, formed by two pieces of tube, and a plano-convex lens, which is moveable, between them, as represented in fig. 5. This valve opens upwards, and suffers the air to pass; but the water cannot return through the tubes, partly because the orifice is capillary, and partly because the flat side of the lens covers the hole. The middle vessel is furnished with a cock *e*, to draw off its contents. The upper vessel *a* is fitted, by grinding, into the upper neck of the middle vessel. Its inferior part consists of a tube that passes almost as low as the centre of the middle vessel. Its upper orifice is closed by a ground stopper *f*. When this apparatus is to be used, the effervescent materials are put into the lower vessel; the middle vessel is filled with pure water, and put into its place; and the upper vessel is stopped, and likewise put in its place. The consequence is, that the carbonic acid gas, passing through the valve at *h*, ascends into the upper part of the middle vessel, *b*, where, by its elasticity, it reacts on the water, and forces part up the tube into the vessel *a*; part of the common air, in this last, being compressed, and the rest escaping by the stopper, which is made of a conical figure, that it may be easily raised. As more carbonic acid is extricated, more water rises, till at length the water in the middle vessel falls below the lower orifice of the tube. The gas then passes through the tube into the upper vessel, and expels more of the common air by raising the stopper. In this situation the water in both vessels being in contact with a body of carbonic acid gas, it becomes strongly impregnated with this gas, after a certain time. This effect may be hastened by taking off the middle and upper vessels together, and agitating them.

The valve is the most defective part of this apparatus; for the capillary tube does not admit the air through, unless there is a considerable quantity condensed in the lower vessel; and the condensation has in some instances burst the vessel.

Modern discoveries respecting bodies in the aëriform state have produced several capital improvements in the vessels used for distillation. It was common with the earliest chemists, to make a small hole in the upper part of their retorts, that the elastic vapours might escape, which would otherwise have burst the vessels. By this means they lost a very considerable part of their products. Sometimes, too, it is requisite to obtain separately the condensable fluid that comes over, and the gases that are, and are not soluble in water. For this purpose a series of receivers, more or less in number as the case may require, is generally employed, as in Pl. VV. fig. 1. which represents what is called Woolfe's apparatus, though in fact its original inventor was Glauber, with some subsequent improvements. The vapour that issues from the retort being condensed in the receiver *a*, the gas passes on through a bent tube into the bottle *c*, which is half filled with water. The gas not absorbed by this water passes through a similar bent tube to *d*, and so on to more, if it be thought necessary; while the gas that is not absorbable by water, or condensable, at its exit from the last bottle is conveyed by a recurved tube into a jar *g*, standing in a mercurial trough *ff*.

It often happens in chemical processes, from the irregularity of the heat, or other circumstances, that the condensation is more rapid in proportion to the supply of vapour at some period of the same operation than in others; which would endanger the fluid's being forced backward, by the pressure of the atmosphere, into the receiver, or even into the retort. To prevent this, Mr. Woolfe's bottles had a central neck, beside the two here delineated, for the insertion of a tube of safety, the lower extremity of which opened underneath the water, and the upper communicated with the atmosphere, so as to supply air in case of sudden absorption. See Plate VV. fig. 3. *h*. Instead of this, however, a curved Welter's tube is now generally used, as more convenient. Into this tube water is poured, till the ball *b*, or *c*, fig. 1. is half full: when absorption takes place, the water rises in the ball till none remains in the tube, and then the air rushes in: on the other hand, no gas can escape, as it has to overcome the pressure of a high column of water in the perpendicular tube.

Another contrivance to prevent retrograde pressure is that of Mr. Pepys. This consists in placing over the first receiver a glass vessel, the neck of which is ground into it, and furnished with a glass valve, similar to that in Nooth's apparatus, so that whenever sudden condensation takes place in the receiver, its effect is merely to occasion a vacuum there.

An ingenious modification of Woolfe's apparatus is that of Mr. Knight, Pl. III. fig. 6. *a a a* represent three vessels, each ground into the mouth of that below it. *b b b*, glass tubes, the middles of which are ground into the neck of their respective vessels, the upper extremity standing above the surface of the liquor in the vessel, and the lower extremity reaching nearly to the bottom of the vessel beneath. *e*, a Welter's tube to prevent absorption. *f*, an adapter ground to fit the receiver; to which any retort may be joined and luted before it is put into its place. *c*, a tube for conveying the gas into a pneumatic trough. The foot of the lowest vessel, *d*, slides in between two grooves in a square wooden foot, to secure the apparatus from oversetting. A stopple fitted to the upper vessel, instead of the adapter *f*, converts it into a Nooth's apparatus, the materials being put into the vessel *a*; and in this case it has the advantage of not having a valve liable to be out of order.

A very simple and commodious form of a Woolfe's apparatus is given by the late Dr. W. Hamilton, at the end of his translation of Berthollet on dyeing; see Pl. VV. fig. 3. *a* is the retort, the neck of which is ground into and passed through the thick collar *b*, represented separately at *b*, with its ground stopple *a*, which may be put in when the neck of the retort is withdrawn. The collar *b* is ground into the wide neck of the receiver *c*, the narrow neck of which is ground into the wide neck of *d*. *d*, *e*, *f*, and *g*, are connected in a similar manner; and into the small necks of *d*, *e*, and *f*, are ground the tubes *i*, *k*, and *l*, so curved, that their lower extremities nearly reach the bottom of the receiver into which they open. From the last receiver proceeds the recurved tube *m*, opening under an inverted cup *n*, a hole in the bottom of which conveys the gas issuing from it into one of the bottles placed in the moveable frame *p*, which has a heavy leaden foot to keep it steady in the centre of a flat pan of water, in which the mouths of the bottles are immersed. In the receiver *d* is a tube of safety *h*. The receivers are placed on a stand a little inclined, and kept steady by slips of wood hollowed out to fit their curvatures, as represented at *s s*. This apparatus requires no lute; has no bent tubes that are difficult to adjust, and liable to break; and the retort may be removed at any stage of the process, either to find the weight it has lost, or for any other purpose, the receiver being meanwhile closed with the stopple. Similar advantages attend Mr. Knight's.

When it is required to pass an aëriform fluid through a red-hot substance, such an apparatus as that of Barruel, Pl. I. fig 2. may be employed. In this, three gun-barrels, *b*, *c*, *d*, are placed horizontally in a reverberatory surface *a*, about two inches distance from each other. From the extremity of the central barrel *c*, a bent tube *k* conveys the gas to the jar *m*, in the pneumatic trough *l*. The other extremity of *c* is connected with *d* by the curved tube *i*; *d* with *b* by the curved tube *h*; and the other end of *b* with the bottle *f* by the tube *e*. When this apparatus is employed for obtaining carbonic oxide, the part of each barrel exposed to the fire being filled with charcoal pressed lightly in, but not rammed hard; carbonate of lime diluted with a very little water being poured into the bottle *f*, and the junctures being all well luted, the fire is to be kindled. As soon as the barrels are red-hot sulphuric acid is to be poured into the funnel *g*, and the carbonic acid gas expelled, traversing three portions of red-hot charcoal, will completely saturate itself with it before it reaches the receiver *m*.

Plate VV. fig. 2. represents the different parts of the apparatus required for measuring the quantity of elastic fluid given out during the action of an acid on calcareous soils. The bottle for containing the soil is represented at *a*; *b*, the bottle containing the acid, furnished with a stop-cock; *c*, the tube connected with a flaccid bladder *d*; *f*, a graduated measure; *e*, the bottle for containing the bladder. When this instrument is used, a given quantity of soil is introduced into *a*; *b* is filled with muriatic acid, diluted with an equal quantity of water; and the stop-cock, being closed, is connected with the upper orifice of *a*, which is ground to receive it. The tube *c* is introduced into the lower orifice of *a*, and the bladder connected with it placed in its flaccid state in *e*, which is filled with water. The graduated measure is placed under the tube of *e*. When the stop-cock of *b* is turned, the acid flows into *a*, and acts upon the soil; the elastic fluid generated passes through *c* into the bladder, and displaces a quantity of water in *c*, equal to it in bulk; and this water flows through the tube into the graduated measure, the water in which gives, by its volume, the indication of the proportion of carbonic acid disengaged from the soil; for every ounce measure of which, two grains of carbonate of lime may be estimated.—*Nicholson.* See CARBONATE, EUDIOMETER, VAPOUR, and APPENDIX.

LABRADOR STONE. See FELSPAR.

LAC is a substance well known in Europe, under the different appellations of stick-lac, shell-lac, and seed-lac. The first is the lac in its natural state, encrusting small branches or twigs. Seed-lac is the stick-lac separated from the twigs, appearing in a granulated form, and probably deprived of part of its colouring matter by boiling. Shell-lac is the substance which has undergone a simple purification, as mentioned below. Beside these we sometimes meet with a fourth, called lump-lac, which is the seed-lac melted and formed into cakes.

Lac is the product of the coccus lacca, which deposits its eggs on the branches of a tree called Bihar, in Assam, a country bordering on Thibet, and elsewhere in India. It appears designed to answer the purpose of defending the eggs from injury, and affording food for the maggot in a more advanced state. It is formed into cells, finished with as much art and regularity as a honeycomb, but differently arranged; and the inhabitants collect it twice a-year, in the months of February and August. For the purification, it is broken into small pieces, and put into a canvass bag of about four feet long, and not above six inches in circumference. Two of these bags are in constant use, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to pass through its pores; when it is taken off the fire and twisted in different directions by the men who hold it, at the same time dragging it along the convex part of a plantain tree prepared for this purpose; and while this is doing, the other bag is heating, to be treated in the same way. The mucilaginous and smooth surface of the plantain tree prevents its adhering; and the degree of pressure regulates the thickness of the coating of lac, at the same time that the fineness of the bag determines its clearness and transparency.

Analyzed by Mr. Hatchett, stick-lac gave in 100 parts, resin 68, colouring extract 10, wax 6, gluten 5.5, extraneous substances 6.5; seed-lac, resin 88.5, colouring extract 2.5, wax 4.5, gluten 2; shell-lac, resin 90.9, colouring extract 0.5, wax 4, gluten 2·8. The gluten greatly resembles that of wheat, if it be not precisely the same; and the wax is analogous to that of the myrica cerifera.

In India, lac is fashioned into rings, beads, and other trinkets; sealing-wax, varnishes, and lakes for painters, are made from it; it is much used as a red dye, and wool tinged with it is employed as a fucus by the ladies; and the resinous part, melted and mixed with about thrice its weight of finely powdered sand, forms polishing stones. The lapidaries mix powder of corundum with it in a similar manner.

The colouring matter is soluble in water; but 1 part of borax to 5 of lac renders the whole soluble by digestion in water, nearly at a boiling heat. This solution is equal for many purposes to spirit varnish, and is an excellent vehicle for water colours, as, when once dried, water has no effect on it. Lixivium of potash, soda, and carbonate of soda, likewise dissolve it. So does nitric acid, if digested upon it in sufficient quantity 48 hours.

The colouring matter of the lac loses considerably of its beauty by keeping any length of time; but when extracted fresh, and precipitated as a lake, it is less liable to injury. Mr. Stephens, a surgeon in Bengal, sent home a great deal prepared in this way, which afforded a good scarlet to cloth previously yellowed with quercitron; but it would probably have been better, if, instead of precipitating with alum, he had employed a solution of tin, or merely evaporated the decoction to dryness.

Lac is the basis of the best sealing-wax.

Shell-lac resin yielded to me in ultimate analysis, carbon 64.67, hydrogen 8.22, oxygen 22.11; in 100 parts.

LACTATES. Definite compounds of lactic acid with the salifiable bases.

LACQUER. Solution of shell-lac in alcohol.

LAKE. This term is used to denote a species of colours formed by precipitating colouring matter with some earth or oxide. The principal lakes are, Carmine, Florence-lake, and lake from Madder.

For the preparation of *Carmine*, four ounces of finely pulverized cochineal are to be poured into four or six quarts of rain or distilled water, that has been previously boiled in a pewter kettle, and boiled with it for the space of six minutes longer; (some advise to add, during the boiling, two drachms of pulverized crystals of tartar). Eight scruples of Roman alum in powder are then to be added, and the whole kept upon the fire one minute longer. As soon as the gross powder has subsided to the bottom, and the decoction is become clear, the latter is to be carefully decanted into large cylindrical glasses, covered over, and kept undisturbed, till a fine powder is observed to have settled at the bottom. The superincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is still much coloured, the rest of the colouring matter may be separated by means of the solution of tin, when it yields a carmine little inferior to the other.

For the preparation of *Florentine* lake, the sediment of cochineal, that remained in the kettle, may be boiled with the requisite quantity of water, and the red liquor likewise, that remained after the preparation of the carmine, mixed with it, and the whole precipitated with the solution of tin. The red precipitate must be frequently edulcorated with water. Exclusively of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with the solution of tin, and the precipitate washed. At the same time, two pounds of alum are also to be dissolved in water, precipitated with a lixivium of potash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter, and dried. For the preparation of a *cheaper* sort, instead of cochineal, one pound of Brazil wood may be employed in the preceding manner.

For the following process for making a *lake from madder*, the Society of Arts voted Sir H. C. Englefield their gold medal. Enclose two ounces troy of the finest Dutch crop madder in a bag of fine and strong calico, large enough to hold three or four times as much. Put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water, cold. Press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it, and when the water is loaded with colour, pour it off. Repeat this process till the water comes off but slightly tinged, for which about five pints will be sufficient. Heat all the liquor in an earthen or silver vessel, till it is near boiling, and then pour it into a large basin, into which a troy ounce of alum dissolved in a pint of boiling soft water has been previously put. Stir the mixture together, and while stirring, pour in gently about an ounce and half of a saturated solution of subcarbonate of potash. Let it stand till cold to settle; pour off the clear yellow liquor; add to the precipitate a quart of boiling soft water, stirring it well; and when cold, separate by filtration the lake, which should weigh half an ounce. If less alum be employed, the colour will be somewhat deeper; with less than three-fourths of an ounce, the whole of the colouring matter will not unite with the alumina. Fresh madder root is equal, if not superior, to the dry.

Almost all vegetable colouring matters may be precipitated into lakes, more or less beautiful, by means of alum or oxide of tin.

LAMP. See LIGHT.

LAMP OF SAFETY, for coal mines, the invaluable and splendid invention of Sir H. Davy. For an account of the principles on which it acts, see COMBUSTION. We shall here describe its construction.

In the parts of coal-mines where danger was apprehended from fire-damp, miners had been accustomed to guide themselves, or to work, by the light afforded by the sparks of steel, struck off from a wheel of flint. But even this apparatus, though much less dangerous than a candle, sometimes produced explosions of the fire-damp.

A perfect security from accident is, however, offered to the miner in the use of a safe-lamp, which transmits its light, and is fed with air, through a cylinder of iron or copper wire-gauze; and this fine invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate.

The apertures in the gauze should not be more than $\frac{1}{20}$ of an inch square. As the fire damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire from $\frac{1}{40}$ to $\frac{1}{60}$ of an inch in diameter is the most convenient.

The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. When it is cylindrical, it should not be more than two inches in diameter; for in larger cylinders, the combustion of the fire-damp renders the top inconveniently hot; and a double top is always a proper precaution, fixed $\frac{1}{2}$ or $\frac{3}{4}$ of an inch above the first top.

The gauze cylinder should be fastened to the lamp by a screw of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; and the security depends upon the circumstance, that no aperture exists in the apparatus, larger than in the wire gauze.

The parts of the lamp are,

1. The brass cistern which contains the oil, pierced near the centre with a vertical narrow tube, nearly filled with a wire which is recurved above, on the level of the burner, to trim the wick, by acting on the lower end of the wire with the fingers. It is called the safety-trimmer.

2. The rim, in which the wire-gauze cover is fixed, and which is fastened to the cistern by a moveable screw.

3. An aperture for supplying oil, fitted with a screw or a cork, and which communicates with the bottom of the cistern by a tube; and a central aperture for the wick.

4. The wire-gauze cylinder, which should not have less than 625 apertures to the square inch.

5. The second top $\frac{3}{4}$ of an inch above the first, surmounted by a brass or copper plate, to which the ring of suspension is fixed.

6. Four or six thick vertical wires, joining the cistern below with the top plate, and serving as protecting pillars round the cage.

When the wire-gauze safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the *first effect* of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms as much as $\frac{1}{12}$ of the volume of the air, the cylinder becomes filled with a feeble blue flame, but the flame of the wick appears burning brightly within the blue flame, and the light of the wick augments till the fire-damp increases to $\frac{1}{6}$ or $\frac{1}{5}$, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light. As long as any *explosive* mixture of gas exists in contact with the lamp, so long it will give light, and when it is extinguished, which happens when the foul air constitutes as much as $\frac{1}{3}$ of the volume of the atmosphere, the air is no longer proper for respiration; for though animal life will continue where flame is extinguished, yet it is always with suffering. By fixing a coil of platinum wire above the wick, ignition will continue in the metal when the lamp itself is extinguished, and from the ignited wire the wick may be again rekindled, on going into a less inflammable atmosphere.

"We have frequently used the lamps where the explosive mixture was so high as to heat the wire-gauze red-hot; but on examining a lamp which has been in constant use for three months, and occasionally subjected to this degree of heat, I cannot perceive that the gauze cylinder of iron wire is at all impaired. I have not, however, thought it prudent, in our present state of experience, to persist in using the lamps under such circumstances, because I have observed, that in such situations the particles of coal dust floating in the air, fire at the gas burning within the cylinder, and fly off in small luminous sparks. This appearance, I must confess, alarmed me in the first instance, but experience soon proved that it was not dangerous.

"Besides the facilities afforded by this invention, to the working of coal-mines abounding in fire-damp, it has enabled the directors and superintendents to ascertain, with the utmost precision and expedition, both the presence, the quantity, and correct situation of the gas. Instead of creeping inch by inch with a candle, as is usual, along the galleries of a mine suspected to contain fire-damp, in order to ascertain its presence, we walk firmly on with the safe-lamps, and, with the utmost confidence, prove the actual state of the mine. By observing attentively the several appearances upon the flame of the lamp, in an examination of this kind, the cause of accidents which happened to the most experienced and cautious miners is completely developed; and this has hitherto been in a great measure matter of mere conjecture.

"It is not necessary that I should enlarge upon the national advantages which must necessarily result from an invention calculated to prolong our supply of mineral coal, because I think them obvious to every reflecting mind; but I cannot conclude without expressing my highest sentiments of admiration for those talents which have developed the properties, and controlled the power, of one of the most dangerous elements which human enterprise has hitherto had to encounter."—See Letter to Sir H. Davy, in Journal of Science, vol. i. p. 302, by John Buddle, Esq. generally and justly esteemed one of the most scientific coal-miners in the kingdom.

LAMPBLACK. The finest lampblack is produced by collecting the smoke from a lamp with a long wick, which supplies more oil than can be perfectly consumed, or by suffering the flame to play against a metalline cover, which impedes the combustion, not only by conducting off part of the heat, but by obstructing the current of air. Lampblack, however, is prepared in a much cheaper way, for the demands of trade. The dregs which remain after the eliquation of pitch, or else small pieces of fir-wood, are burned in furnaces of a peculiar construction, the smoke of which is made to pass through a long horizontal flue, terminating in a close-boarded chamber. The roof of this chamber is made of coarse cloth, through which the current of air escapes, while the soot remains.

LANA PHILOSOPHICA. The snowy flakes of white oxide, which rise and float in the air from the combustion of zinc.

LAPIS INFERNALIS. Potash.

LAPIS LAZULI. Azure-stone.

LAPIS NEPHRITICUS. See NEPHRITE.

LAPIS OLLARIS. Potstone.

LATIALITE. Haüyne.

LATROBITE. A new mineral of a pale pink colour. It occurs massive and crystallized. It scratches glass, and is scratched by felspar. Sp. grav. 2.8. It was found in Amitok island, near the coast of Labrador, by the Rev. Mr. Latrobe.

LAVA. See VOLCANIC PRODUCTS.

LAZULI (LAPIS). Azure-stone.

LEAD is a white metal of a considerably blue tinge, very soft and flexible, not very tenacious, and consequently incapable of being drawn into fine wire, though it is easily extended into thin plates under the hammer. Its sp. gr. is 11.35. It melts at 612°. In a strong heat it boils, and emits fumes, during which time, if exposed to the air, its oxidation proceeds with considerable rapidity. Lead is brittle at the time of congelation. In this state it may be broken to pieces with a hammer, and the crystallization of its internal parts will exhibit an arrangement in parallel lines.

Lead is not much altered by exposure to air or water, though the brightness of its surface, when cut or scraped, very soon goes off. It is probable that a thin stratum of oxide is formed on the surface, which defends the rest of the metal from corrosion.

There are certainly two, perhaps three oxides of lead:—

1. The powder precipitated by potash from the solution of the nitrate of lead, being dried, forms the yellow protoxide. When somewhat vitrified, it constitutes litharge, and, combined with carbonic acid, white-lead or ceruse. It has been obtained by M. Houton-Labillardiere, in dodecahedral white crystals, about the size of a pin-head, by slow deposition, from a solution of litharge in soda. Heat volatilizes it. It is of very much importance to know accurately the composition of this oxide of lead, especially in consequence of its great influence in the analysis of organic bodies. The mean of Berzelius's last experiments, as detailed in the 5th vol. of the *Afhandlingar i Fysik*, and translated into the Ann. of Phil. for February 1820, gives us 7·73 for the quantity of oxygen, combined with 100 of lead in 107.73 of the protoxide, whence the prime equivalent of lead comes out 12.9366. The very near approach of this to 13, will justify us in adopting this round number; and in estimating the equivalent of the protoxide at 14. The pigment massicot is merely this oxide.

2. When massicot has been exposed for about 48 hours to the flame of a reverberatory furnace, it becomes red-lead, or minium. This substance has a sp. gr. of 8.94. At a red heat it gives out oxygen, and passes into vitrified protoxide. It consists of 100 lead + 11.08 oxygen; and it may be represented as a compound of 2 primes of lead + 3 oxygen; or of 1 prime protoxide + 1 prime peroxide.

3. If upon 100 parts of red-lead we digest nitric acid of the sp. gr. 1.26, 92 5 parts will be dissolved, but 7·5 of a dark brown powder will remain insoluble. This is the peroxide of lead, and consists of 100 lead + 15.4 oxygen; or 13 + 2 = 15.

By passing a stream of chlorine through red-lead diffused in water, we obtain a solution, which yields by potash an abundant precipitate of the brown oxide of lead. From 100 of minium, 68 of the peroxide may be obtained. It is tasteless, and with muriatic acid evolves chlorine. When heated, oxygen is disengaged, and protoxide remains. The red-lead of commerce is often very impure, containing yellow oxide, sulphate of lead, submuriate of lead, and silica.

Chloride of lead is formed either by placing lead in chlorine, or by exposing the muriate to a moderate heat. It is a semitransparent greyish-white mass, somewhat like horn, whence the old name of *plumbum corneum*. It is fixed at a red heat in close vessels, but it evaporates at that temperature in the open air. By Dr. Davy's analysis, it consists of chlorine 25.78 + lead 74.22; or 4.5 + 13.

The iodide is easily formed, by heating the two constituents. It has a fine yellow colour. It precipitates when we pour hydriodate of potash into a solution of nitrate of lead.

The salts of lead have the protoxide for their base, and are distinguishable by the following general characters:—

1. The salts which dissolve in water usually give colourless solutions, which have an astringent sweetish taste.

2. Placed on charcoal they all yield, by the blowpipe, a button of lead.

3. Ferroprussiate of potash occasions in their solutions a white precipitate.

4. Hydrosulphuret of potash, a black precipitate.

5. Sulphuretted hydrogen, a black precipitate.

6. Gallic acid, and infusion of galls, a white precipitate.

7. A plate of zinc, a white precipitate, or metallic lead.

Most of the acids attack lead. The sulphuric does not act upon it, unless it be concentrated and boiling. Sulphurous acid gas escapes during this process, and the acid is decomposed. When the distillation is carried on to dryness, a saline white mass remains, a small portion of which is soluble in water, and is the sulphate of lead; it affords crystals. The residue of the white mass is an insoluble sulphate of lead. It consists of 5 acid + 14 protoxide.

Nitric acid acts strongly on lead.

The nitrate solution, by evaporation, yields tetrahedral crystals, which are white, opaque, possess considerable lustre, and have a sp. gr. of 4. They dissolve in 7.6 parts of boiling water. They consist of 6.75 acid + 14 protoxide; or nearly 1 + 2.

A *subnitrate* may be formed in pearl-coloured scales, by boiling in water equal weights of the nitrate and protoxide.

A subnitrate of lead may be formed, by boiling a solution of 10 parts of the nitrate on 7.8 of metallic lead. If more of the metal be used, a quadro-subnitrate results. By saturating one-half of the oxide of the subnitrate, with the equivalent proportion of sulphuric acid, a neutral nitrate is formed.

Muriatic acid acts directly on lead by heat, oxidizing it, and dissolving part of its oxide.

The acetic acid dissolves lead and its oxides; though probably the access of air may be necessary to the solution of the metal itself in this acid. *White-lead*, or *ceruse*, is made by rolling leaden plates spirally up, so as to leave the space of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered, and exposed for a length of time to a gentle heat in a sand-bath, or by bedding them in dung. The vapour of the vinegar, assisted by the tendency of the lead to combine with the oxygen which is present, corrodes the lead, and converts the external portion into a white substance which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly, until they are corroded through. Ceruse is the only white used in oil paintings. Commonly it is adulterated with a mixture of chalk in the shops. It may be dissolved without difficulty in the acetic acid, and affords a crystallizable salt, called *sugar of lead*, from its sweet taste. This, like all the preparations of lead, is a deadly poison. The common sugar of lead is an acetate; and Goulard's extract, made by boiling litharge in vinegar, a subacetate. The power of this salt, as coagulator of mucus, is superior to the other. If a bit of zinc be suspended by brass or iron wire, or a thread, in a mixture of water and the acetate of lead, the lead will be revived, and form an arbor Saturni.

The acetate, or sugar of lead, is usually crystallized in needles, which have a silky appearance. They are flat four-sided prisms with dihedral summits. Its sp. gr. is 2.345. It is soluble in three and a half times its weight of cold water, and in somewhat less of boiling water. Its constituents are 26.96 acid + 58.71 base + 14.32 water.—*Berzelius.*

The subacetate crystallizes in plates, and is composed of 20 acid + 80 base; or 1 prime + 2. The sulphuret, sulphate, carbonate, phosphate, arseniate, and chromate of lead, are found native, and will be described among its ORES.

When lead is alloyed with an equal weight of tin, or perhaps even less, it ceases to be acted on by vinegar. Acetate and subacetate of lead in solution have been used as external applications to inflamed surfaces, and scrofulous sores, and as eye-washes. In some extreme cases of hæmorrhagy from the lungs and bowels, and uterus, the former salt has been prescribed, but rarely and in minute doses, as a corrugant or astringent. The colic of the painters, and that formerly prevalent in certain counties of England, from the lead used in the cyder presses, show the very deleterious operation of the oxide, or salts of this metal, when habitually introduced into the system in the minutest quantities at a time. Contraction of the thumbs, paralysis of the hand, or even of the extremities, have not unfrequently supervened. A course of sulphuretted hydrogen waters, laxatives, of which sulphur, castor-oil, sulphate of magnesia, or calomel, should be preferred, a mercurial course, the hot sea-bath, and electricity, are the appropriate remedies.

Dealers in wines have occasionally sweetened them, when acescent, with litharge or its salts. This deleterious adulteration may be detected by sulphuretted hydrogen water, which will throw down the lead in the state of a dark brown sulphuret. Or, subcarbonate of ammonia, which is a very delicate test, may be employed to precipitate the lead in the state of a white carbonate; which, on being washed and digested with sulphuretted hydrogen water, will instantly become black. If the white precipitate be gently heated, it will become yellow, and, on charcoal before the blowpipe, it will yield a globule of lead. Chromate of potash will throw down from saturnine solutions a beautiful orange-yellow powder. Burgundy wine, and all such as contain tartar, will not hold lead in solution, in consequence of the insolubility of the tartrate.

The proper counter-poison for a dangerous dose of sugar of lead, is solution of Epsom or Glauber salt, liberally swallowed; either of which medicines instantly converts the poisonous acetate of lead into the inert and innoxious sulphate. The sulphuret of potash, so much extolled by Navier, instead of being an antidote, acts itself as a poison on the stomach.

Sugar has been found to neutralize the poisonous action of acetate of lead; and therefore may be regarded as an excellent antidote to it. Sugar readily dissolves the protoxide of lead; and it deprives the brown oxide of its excess of oxygen, and then dissolves it. *Vogel.*

Oils dissolve the oxide of lead, and become thick and consistent; in which state they are used as the basis of plasters, cements for water-works, paints, &c.

Sulphur readily dissolves lead in the dry way, and produces a brittle compound, of a deep grey colour and brilliant appearance, which is much less fusible than lead itself; a property which is common to all the combinations of sulphur with the more fusible metals.

The phosphoric acid, exposed to heat together with charcoal and lead, becomes converted into phosphorus, which combines with the metal. This combination does not greatly differ from ordinary lead: it is malleable, and easily cut with a knife; but it loses its brilliancy more speedily than pure lead; and when fused upon charcoal with the blowpipe, the phosphorus burns, and leaves the lead behind.

Litharge fused with common salt decomposes it; the lead unites with the muriatic acid, and forms a yellow compound, used as a pigment. The same decomposition takes place in the humid way, if common salt be macerated with litharge; and the solution will contain caustic alkali.

Lead unites with most of the metals. Gold and silver are dissolved by it in a slight red heat. Both these metals are said to be rendered brittle by a small admixture of lead, though lead itself is rendered more ductile by a small quantity of them. Platina forms a brittle compound with lead; mercury amalgamates with it; but the lead is separated from the mercury by agitation, in the form of an impalpable black powder, oxygen being at the same time absorbed. Copper and lead do not unite but with a strong heat. If lead be heated so as to boil and smoke, it soon dissolves pieces of copper thrown into it; the mixture, when cold, is brittle. The union of these two metals is remarkably slight; for, upon exposing the mass to a heat no greater than that in which lead melts, the lead almost entirely runs off by itself. This process is called eliquation. The coarser sorts of lead, which owe their brittleness and granulated texture to an admixture of copper, throw it up to the surface on being melted by a small heat. Iron does not unite with lead, as long as both substances retain their metallic form. Tin unites very easily with this metal, and forms a compound, which is much more fusible than lead by itself, and is, for this reason, used as a solder for lead. Two parts of lead and one of tin form an alloy more fusible than either metal alone: this is the solder of the plumbers. Bismuth combines readily with lead, and affords a metal of a fine close grain, but very brittle. A mixture of eight parts bismuth, five lead, and three tin, will melt in a heat which is not sufficient to cause water to boil. Antimony forms a brittle alloy with lead. Nickel, cobalt, manganese, and zinc, do not unite with lead by fusion.

All the oxides of lead are easily revived with heat and carbon.

LEATHER. The skins of animals prepared by maceration in lime water, and afterwards combined with astringent substances. See TANNING.

LEAVES OF PLANTS. See CHLOROPHYLE.

LEELITE. A red siliceous stone found at Gryphytta in Westmannia. It has the same lustre and translucency as horn. Fracture splintery. Sp. grav. 2·71. Its constituents are silica 75; alumina 22; manganese 2·5; water 0·5. *Dr. Clarke.*

LEES (SOAP). See POTASH; also SOAP.

LEMONS. See ACID (CITRIC).

LEMNIAN EARTH, or SPHRAGIDE. Colour yellowish-gray, and frequently marbled with rusty spots. Dull. Fracture fine earthy. Meagre to the feel. Adheres slightly to the tongue. When plunged in water, it falls to pieces with disengagement of air-bubbles. Its constituents are, 66 silica, 14·5 alumina, 0·25 magnesia, 0·25 lime, 3·5 soda, 6 oxide of iron, 8·5 water.—*Klaproth.* It has hitherto been found only in the island of Stalimene (ancient Lemnos). It is reckoned a medicine in Turkey; and is dug up only once a-year, with religious solemnities, cut into spindle-shaped pieces, and stamped with a seal. It was esteemed an antidote to poison and the plague in Homer's time; a virtue to which it has not the slightest claim.

LENZINITE. 1. *Opaline.* A mineral of a milk-white colour, in small pieces, smooth and slightly greasy to the touch, and surface not shining. Fracture conchoidal; transparent on the edges. Moderately hard; sectile. Adheres to the tongue. Sp. grav. 2·10. It cracks asunder with a noise in water. It consists of silica 37·5; alumina 37·5; water 25. *Johns.* 2. *Argillaceous.* Colour snow-white, sometimes tinged yellow with iron. Fracture earthy. Slightly coherent; adheres strongly to the tongue. Sp. grav. 1·8. Like the preceding, when exposed to a red heat, it becomes hard enough to scratch glass. It is composed of silica 39; alumina 35·5; water 25; lime 0·05. *Johns.* Found at Kall, in Eifeld.

LEPIDOLITE. Colour peach-blossom red, sometimes grey. Massive, and in small concretions. Lustre glistening, pearly. Cleavage single. Fracture coarse splintery. Feebly translucent. Soft. Rather sectile. Rather easily frangible. Sp. gr. 2·6 to 2·8. It intumesces before the blowpipe, and melts easily into a milk-white translucent globule. Its constituents are, 54 silica, 20 alumina, 18 potash, 4 fluate of lime, 3 manganese, and 1 iron.—*Vauquelin.* It occurs in limestone at Dalmally, and on the north side of Lochfine; on the east side of Lochleven, nearly opposite the inn at Balachulish. It is found in many places on the continent. On account of its beautiful colour, it has been cut into snuff-boxes, but it is rather soft and greasy to the aspect.—*Jameson.*

LEUCITE. Dodecahedral zeolite of Jameson. Colour white, whence its name. Generally in roundish imbedded grains, or crystallized in acute double eight-sided pyramids. Internal lustre shining. Cleavage imperfect. Fracture imperfect conchoidal. Translucent. Refracts single. Harder than apatite, but softer than felspar. Brittle. Sp. gr. 2·5. With borax it fuses into a brownish transparent glass. Its constituents are, 56 silica, 20 alumina, 20 potash, 2 lime, and 2 loss.—*Vauquelin.* It is almost peculiar to Italy, occurring in trap-rocks and lavas, at Albano, Frascati, and near Naples.

LEUTTRITE. A mineral brought from Leuttra, near Jena, in Saxony. It appears to be a recomposed rock, analogous to some of the sandy varieties of the Domite. Colour greyish-white, tinged here and there of an ochrey brown.

LEVEYNE. A new mineral, which occurs in the cavities of an amygdaloid rock, from Dalsnypen in Faroe. Cleavage indistinct. Fracture imperfectly conchoidal. Lustre vitreous. Colour and streak white. Semi-transparent. Brittle. In minute crystals. *Edin. Journal of Science for April,* 1825.

LEVIGATION. The mechanical process of grinding the parts of bodies to a fine paste, by rubbing the flat face of a stone called the muller, upon a table or slab called the stone. Some fluid is always added in this process. The advantage of levigation with a stone and muller, beyond that of triturating in a mortar, is, that the materials can more easily be scraped together, and subjected to the action of the muller, than in the other case to that of the pestle; and, from the flatness of the two surfaces, they cannot elude the pressure.

LHERZOLITE. Coccolite mixed with serpentine.

LIAS limestone is argillo-ferruginous, enclosing ammonites, and great variety of sea-shells. Its geological situation is under the oolite, as near Bath. It is used in the lithographic art.

LIBAVIUS, smoking liquor of; deutochloride of tin.

LICHNITES. The ancient name of Parian marble.

LIEVRITE, OR YENITE. Colour black. Massive; in distinct concretions; and crystallized; in oblique or almost rectangular four-sided prisms, varying from acicular to the thickness of an inch. Lateral planes longitudinally streaked. Lustre glistening, semi-metallic. Fracture uneven. Opaque. Scratches glass, and gives a few sparks with steel, but is scratched by adularia. Streak unchanged. Easily frangible. Sp. gr. 3·9. Magnetic on being heated; its colour at the same time changing to reddish-brown. It melts into an opaque black bead, having a metallic aspect, and magnetic. Its constituents are, 30 silica, 12·5 lime, 57·5 oxide of iron and oxide of manganese, the last of which forming only 2 or 3 parts. It occurs in primitive limestone in the island of Elba.

LIEVRITE. Colour blackish-green. Massive; in distinct concretions; and crystallized in oblique four-sided prisms. Lustre of the fracture glistening, and semi-metallic. Fracture uneven. Opaque. Sp. gr. 4·0. Its constituents are, silica 30, alumina 1, lime 14·8, oxide of iron 49, oxide of manganese 2.—*Vauquelin*. It occurs in primitive limestone along with epidote, quartz, &c. in the island of Elba.—*Jameson*.

LIGHT. The agent of vision.

Some philosophers regard light as consisting of particles of inconceivable minuteness, emitted in succession by luminous bodies, which move in straight lines, at the rate of 200,000 miles per second.

Others conceive that it consists in certain undulations, communicated by luminous bodies to an ethereal fluid which fills all space. This fluid is composed of the most subtile matter, is highly elastic, and the undulations are propagated through it with great velocity, in spherical superficies proceeding from a centre. This view derives great plausibility from its happy application by Huygens, to explain a very difficult class of optical phenomena, the double refraction of calcareous spar and other bodies.

The *common* refraction is explained by Huygens on the supposition, that the undulations in the luminous fluid are propagated in the form of *spherical* waves. The *double* refraction is explained on the supposition, that the undulations of light, in passing through the calcareous spar, assume a *spheroidal* form; and this hypothesis, though it does not apply with the same simplicity as the former, yet admits of such precision, that a proportion of the axes of the spheroids may be assigned, which will account for the precise quantity of the extraordinary refraction, and for all the phenomena dependent on it, which Huygens had studied with great care, and had reduced to the smallest number of general facts.

"That these spheroidal undulations actually exist," says the celebrated Playfair, "he would after all be a bold theorist who should affirm; but that the supposition of their existence is an accurate expression of the phenomena of double refraction, cannot be doubted. When one enunciates the hypothesis of the spheroidal undulations, he in fact expresses in a single sentence all the phenomena of double refraction. The hypothesis is therefore the means of representing these phenomena, and the laws which they obey, to the imagination or the understanding; and there is perhaps no theory in optics, and but very few in natural philosophy, of which more can be said. Theory therefore, in this instance, is merely to be regarded as the expression of a general law, and in that light I think it is considered by La Place."

Dr. Young has selected from Sir Isaac Newton's various writings, many passages favourable to the admission of the undulatory theory of light, or of a luminiferous ether pervading the universe, rare and elastic in a high degree. "Is not the heat (of the warm room) conveyed through the vacuum by the vibrations of a much subtiler medium than air? And is not this medium the same with that medium by which light is reflected and refracted, and by whose vibrations light communicates heat to bodies, and is put into fits of easy reflexion and easy transmission? And do not the vibrations of this medium in hot bodies contribute to the intenseness and duration of their heat? And do not hot bodies communicate their heat to contiguous cold ones, by the vibrations of this medium, propagated from them into the cold ones? And is not this medium exceedingly more rare and subtile than the air, and exceedingly more elastic and active? And doth it not readily pervade all bodies? And is it not by its elastic force expanded through all the heavens?"—"If any one would ask how a medium can be so rare, let him tell me how an electric body can by friction emit an exhalation so rare and subtile, and yet so potent? And how the effluvia of a magnet can pass through a plate of glass without resistance, and yet turn a magnetic needle beyond the glass?"—*Optics*, *Qu*. 18. 22. "Were I to assume an hypothesis, it should be this, if propounded more generally, so as not to determine what light is, farther than that it is something or other capable of exciting vibrations in the ether; for thus it will become so general, and comprehensive of other hypotheses, as to leave little room for new ones to be invented."—*Birch*, iii. 249.

Dr. Young shows, that many phenomena inexplicable on the notion of radiating corpuscles, are easily reconciled to the theory of undulation. "On the whole," says this profound philosopher, "it appears that the few optical phenomena, which admit of explanation by the corpuscular system, are equally consistent with this theory; that many others which have been long known, but never understood, become by these means perfectly intelligible; and that several new facts are found to be thus, only, reducible to a perfect analogy with other facts, and to the simple principles of the undulatory system."—*Nat. Phil.* vol. ii. p. 631.

That the new discoveries on polarized light may be more easily referred to the corpuscular than undulatory hypothesis, has been too hastily asserted.

The physical affections of light are foreign to this work. Its chemical relations are alone to be considered. These may be conveniently referred to four heads:—

1. Of the mean refractive and dispersive powers of different bodies.

2. Of the action of the different prismatic colours on chemical matter.

3. Of the polarization of light.

4. Of the absorption and disengagement of light, or phosphorescence.

I. Newton first discovered that certain bodies exercise on light a peculiar attractive force. When a ray passes obliquely from air into any transparent liquid or solid surface, it undergoes at entrance an angular flexure, which is called *refraction*. The variation of this departure from the rectilineal path for any particular substance, depends on the obliquity of the ray to the refracting surface; so that the sine of the angle of refraction is to that of the angle of incidence, in a constant ratio. Now Newton found, that unctuous or inflammable bodies occasioned a greater deviation in the luminous rays than their attractive mass or density gave reason to expect. Hence he conjectured, that both diamond and water contained combustible matter,—a sagacious anticipation of future chemical discovery.

Dr. Wollaston invented a very ingenious apparatus, in which, by means of a rectangular prism of flint glass, the index of refraction of each substance is read off at once by a vernier, the three sides of a moveable triangle performing the operations of reduction, in a very compendious manner.—*Phil. Trans.* 1802, or *Nicholson's Journal*, 8vo. vol. iv. p. 89.

But transparent media occasion not merely a certain flexure of the white sunbeam, called the *mean refraction*, they likewise decompose it into its constituent colours. This effect is called *dispersion*. Now the mean refractive and dispersive powers of bodies are not proportional to each other. In some refracting media, the mean angle of refraction is larger, whilst the angle of dispersion is smaller; and in other refracting media, the mean angle of refraction is smaller, whilst the angle of dispersion is larger. In short, the knowledge of the mean refractive power of a given substance will not enable us to determine its dispersive power, and *vice versa*.

From the refractive power of bodies we may in many cases infer their chemical constitution. For discovering the purity of essential oils, an examination with Dr. Wollaston's instrument may be of considerable utility, on account of the smallness of the quantity requisite for trial. "In oil of cloves, for instance, I have met with a wide difference. The refractive power of genuine oil of cloves is as high as 1·535; but I have also purchased oil by this name which did not exceed 1·498, and which had probably been adulterated by some less refractive oil." This fine idea, suggested by Dr. Wollaston, has been happily prosecuted by M. Biot, with regard to gaseous compounds. I shall first give general tables of the refractive and dispersive powers of different bodies, and then make some remarks on their chemical applications:—

		Index of Refraction.
A vacuum,		1·00000
Atmospheric air, (mean),		1·00033
Ice,	W.	1·31000
Ice,	Brewster,	1·30700
Water, }		1·336
Vitreous humour, } Cryolite,	B.	1·344
Ether,	Wol.	1·358
Albumen,	W.	1·360
Alcohol,	W.	1·370
Saturated solut. of salt,	Cavallo,	1·375
Solution of sal ammoniac,		1·382
Nitric acid, sp. gr. 1·48,	W.	1·410
Fluor spar,	W.	1·433
Sulphuric spar,	W.	1·435
Spermaceti, melted,	W.	1·446
Crystalline lens of an ox,	W.	1·447
Alum,	W.	1·457
Tallow melted,	W.	1·460
Borax,	C.	1·467
Oil of lavender,	W.	1·467
	C.	(1·469)
Oil of peppermint,	W.	1·468
Oil of olives,	W.	1·469
Oil of almonds,	W.	1·470
Oil of turpentine, rectified,	W.	1·470
Do. common,	W.	1·476
Essence of lemon,	W.	1·476
Butter, cold,	W.	1·480
Linseed oil,	W.	1·485
Camphor,	W.	1·487
Iceland spar, weakest refr.	W.	1·488
Do. strongest do.	W.	(1·657)

		Index of Refraction.
Tallow, cold,	W.	1·49
Sulphate of potash,	W.	1·495
Oil of nutmeg,	W.	1·497
French plate-glass,	W.	1·500
English plate-glass,	W.	1·504
Oil of amber,	W.	1·505
Balsam of capivi,	W.	1·507
Gum-arabic,	W.	1·514
Dutch plate-glass,	W.	1·517
Caoutchouc,	W.	1·524
Nitre,	C.	1·524
Selenite,	W.	1·525
Crown-glass, common,	W.	1·525
Canada balsam,	W.	1·528
Centre of the crystalline of fish, and dry crystalline of an ox,	W.	1·530
Pitch,	W.	
Radcliffe crown-glass,	W.	1·533
Anime,	W.	1·535
Copal,	W.	1·535
Oil of cloves,	W.	1·535
White wax, cold,	W.	
Elemi,		
Mastic,		
Arseniate of potash,		
Sugar, after fusion,		
Spermaceti, cold,		
Red sealing-wax,		
Oil of sassafras,	W.	1·536
Bees-wax,	W.	1.542
Boxwood,	W.	
Colophony,	W.	1·543
Old plate-glass,	W.	1.545
Rock crystal, (double),	W.	1·547
Amber,	W.	1·547
	C.	(1·556)
Opium,	W.	
Mica,	W.	
Phosphorus,	W.	1·579
Horn,	W.	
Flint-glass,	W.	1·583 1·586
Benzoin,	W.	
Guaiacum,	W.	1·596
Balsam of Tolu,	W.	1·600
Sulphate of barytes, (double R.)	W.	1·646
Iceland spar, (strongest),	W.	1·657
Gum dragon,	W.	
Carburet of sulphur,	Br.	1·680
White sapphire,	W.	1·768
Muriate of antimony, variable,	W.	
Arsenic, (a good test),	W.	1·811
Spinelle ruby,	W.	1·812
Jargon,	W.	1·950
Glass of antimony,	W.	1·980
Native sulphur,	W.	2·040
Do.	Brewster,	2·115
Plumbago,	W.	
Phosphorus,	Brewster,	2·224
Diamond,	Newton, by Dr. W.	2·440
Do.	Rochon,	2·755
Realgar,	Brewster,	2·510
Chromate of lead, (least refr.),	do.	2·479
Do. (greatest refr.),	do.	2·926

TABLE II.—*Refracting Powers of Gases for the temperature of 32° F. and pressure 30, by MM. Biot and Arago.*

Atmospheric air	1·00000
Oxygen	0·86161
Azote	1·03408
Hydrogen	6·61436
Ammonia	2·16851
Carbonic acid	1·00476
Subcarburetted hydrogen	2·09270
Muriatic acid gas	1·19625

The following table of the refractive powers of gases at the same temperature and pressure, that of air being taken at unity, is given by M. Dulong:

	Refractive power.	Density.
Atmospheric air	1·	1.
Oxygen	0·924	1·1026
Hydrogen	0·470	0·0685
Azote	1·020	0·9760
Chlorine	2·623	2·47
Oxide of azote	1·710	1·527
Nitrous gas	1·030	1·039
Muriatic acid	1·527	1·254
Oxide of carbon	1·157	0·972
Carbonic acid	1·526	1·524
Cyanogen	2·832	1·818
Olefiant gas	2·302	0·980
Gas of marshes	1·504	0·559
Muriatic ether	3·720	2·234
Hydrocyanic acid	1·531	0·944
Ammonia	1·309	0·591
Oxi-chloro-carbonic	3·936	3·442
Sulphuretted hydrogen	2·187	1·178
Sulphurous acid	2·260	2·247
Sulphuric ether	5·197	2·580
Carburet of sulphur	5·110	2·644
Sub-phosphuret. hydrogen	2·682	1·256

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TABLE III.—*Dispersive Powers.*

Cryolite,	Brewster,	0·022
Fluor spar,	do.	0·022
Water,	do.	0·035
Diamond,	do.	0·038
Flint-glass, (highest),	do.	0·052
Carburet of sulphur,	do.	0·115
Phosphorus,	do.	0·128
Sulphur,	do.	0·130
Oil of cassia,	do.	0·139
Realgar,	do.	0·255
Chromate of lead, (least refr.)	do.	0·262
Do. (greatest refr.)	do.	0·400

Carburet of sulphur exceeds all fluid bodies in refractive power, surpassing even flint-glass, topaz, and tourmaline; and in dispersive power it exceeds every fluid substance, except oil of cassia, holding an intermediate place between phosphorus and balsam of Tolu.

Dr. Brewster has further shown, that all doubly refracting crystals have two dispersive powers.

From Table II. it appears that the refractive power of hydrogen gas greatly surpasses not only that of the other gases, but of all known bodies. This principle exists in great abundance in resins, oils, and gums, where it is united to carbon and oxygen; and we must probably ascribe to it the eminent refractive power of these combustibles, so justly observed by Newton. This effect of hydrogen is finely displayed in ammonia, whose refractive power is more than double that of air; and much superior to that of water.

But since every substance ought to introduce into its combinations its peculiar character, and preserve in them to a certain degree the force with which it acts on light, let us endeavour to calculate, in this point of view, the refractive influence of the constituents of a compound. From our knowledge of the extreme tenuity of light, it is probable, that the influence of a moderate chemical condensation ought to affect its operations very slightly; for whether it be an ether or a corpuscular emanation, the excessive minuteness of its particles, compared to the distances between the molecules of bodies, ought to render the change of distance among the latter unimportant. Consequently, the refracting powers of bodies ought to differ very little from those of their elements, unless a very great degree of condensation has taken place.

Hence, if we multiply the proportions of azote and oxygen respectively, by their refractive powers, we shall obtain products, whose sums will coincide with the refractive power of the atmosphere. Thus, 100 parts by weight of the atmosphere, consist of azote 77·77 + oxygen 22·22. If we multiply each of these numbers by the number representing the refractive power of the body, and making a small correction for the carbonic acid present, we shall have for the sum of the products 1·0000.

Ammonia, however, furnishes a more interesting example of the application of these principles.

The refractive power of hydrogen is, . . .	6·61436
of azote,	1·03408
of ammonia,	2·16851

Let x be the weight of the constituent, whose refractive power is a

$y = 100 - x =$ that whose power is b

and call the refractive power of the compound c

Then $x = \frac{c - b}{a - b}$. In the present case,

$$x = \frac{2\cdot16851 - 1\cdot03408}{6\cdot61436 - 1\cdot03408} = 0\cdot203, \text{ and}$$

$100 - x = 0\cdot797 =$ the azote in 100 parts of ammonia; which may be regarded as an approximation. The true proportions given by the equivalent ratios are, 0·823 azote + 0·177 hydrogen. If the refractive power of ammonia were 2·0218, then the chemical and optical analysis would coincide.

If we calculate, on the above data, what ought to be the refractive power of water, as a compound of 8 parts of oxygen + 1 hydrogen, we shall obtain the number 1.50065, which being multiplied by 0.45302, the absolute refractive power of air, when we take the density of water for unity, we shall have a product = 0.67984. Now, according to Newton's estimate, which M. Biot has found to be exact, the refractive power of water is 0.7845. Hence we see, that the compound has acquired an increased refractive force by condensation, above the mean of its constituents, in the ratio of 100 to $86\frac{2}{3}$.

Rays of light, in traversing the greater number of crystallized bodies, are commonly split into two pencils; one of which, called the ordinary ray, follows the common laws of refraction, agreeably to the preceding tables, whilst the other, called the extraordinary ray, obeys very different laws. This phenomenon is produced in all transparent crystals, whose primitive form is neither a cube nor a regular octohedron. The division of the beam is greater or less, according to the nature of the crystal, and the direction in which it is cut. But of all known substances, that which produces this phenomenon in the most energetic manner is the rhomboidal carbonate of lime, commonly called island spar.

II. Of the action of the different *coloured* rays. If the white sunbeam, admitted through a small hole of a window-shutter into a darkened room, be made to pass through a triangular prism of glass, it will be divided into a number of splendid colours, which may be thrown upon a sheet of paper. Newton ascertained, that if this coloured image, or spectrum as it is called, be divided into 360 parts, the red will occupy 45, the orange 27, the yellow 48, the green 60, the blue 60, the indigo 40, and the violet 80. The red rays being least bent by the prism from the direction of the white beam, are said to be least refracted, or the least refrangible; while the violet rays being always at the other extremity of the spectrum, are called the most refrangible. According to Dr. Wollaston, when the beam of light is only 1-20th of an inch broad, and received by the eye at the distance of 10 feet through a clear prism of flint glass, only four colours appear, red, yellowish-green, blue, and violet.

If the differently coloured rays of light thus separated by the prism be concentred on one spot by a lens, they will reproduce colourless light. Newton ascribes the different colours of bodies, to their power of absorbing all the primitive colours except the peculiar one which they reflect, and of which colour they therefore appear to our eye.

According to Sir William Herschel, the

different coloured rays possess very different powers of illumination. The lightest green, or deepest yellow, which are near the centre, throw more light on a printed page than any of the rays towards either side of the spectrum. Sir H. Davy remarks, that as there are *more* green rays in a given part of the spectrum than blue rays, the difference of illuminating power may depend on this circumstance. The rays separated by one prism are not capable of being further divided by being passed through another; and in their relations to double refraction and reflection they appear to agree with direct light. An object illuminated by any of the rays in the spectrum is seen double through island crystal, in the same manner as if it had been visible by white light.

Under CALORIC, we have stated the power of heating which the different coloured rays of the spectrum apparently possess. Sir H. Englefield, and M. Berard, confirmed the results of Sir W. Herschel, with regard to the progressive increase of calorific influence from the violet, to the red extremity of the spectrum; and they also found with him, that a calorific influence extended beyond the limit of the red light, into the unilluminated space. M. Berard, however, observed, that the maximum of effect was *in* the light, and not *beyond* it. This ingenious philosopher made a pencil of the sunbeam pass across a prism of island spar. The division of the rays formed two *spectra*, which presented the same properties with the single spectrum. Both possessed the calorific virtue in the same manner and degree. M. Berard polarized a beam of light by reflection from a mirror; and he found that in all the positions in which light ceased to be reflected, heat also ceased to appear. The thermometer in the focus of the apparatus was no longer affected. Thus we see, that the obscure heat-making principle accompanies the luminous particles, and obeys the same laws of action.

If the white *luna cornea*, the muriate of silver moistened, be exposed to the different rays in the prismatic spectrum, it will be found, that no effect is produced upon it in the least refrangible rays, which occasion heat without light; that only a slight discoloration will be occasioned by the red rays; that the blackening power will be greater in the violet than in any other ray; and that beyond the violet, in a space perfectly obscure to our eyes, the darkening effect will be manifest on the muriate.

This observation, due to M. Ritter and Dr. Wollaston, proves, that there are rays more refrangible than the rays producing light and heat. As it appears, from the observations of M. Berthollet, that muriatic acid gas is formed when horn-silver is blackened by light, the above rays may be called hydrogenating. Sir H. Davy found, that a mixture of chlorine and hydrogen acted more rapidly upon each other, combining without explosion, when exposed to the red rays, than when placed in the violet rays; but that solution of chlorine in water became solution of muriatic acid most rapidly, when placed in the most refrangible rays in the spectrum. He also observed, that the puce-coloured oxide of lead, when moistened, gradually gained a tint of red in the least refrangible rays, and at last became black, but was not affected in the most refrangible rays. The same change was produced by exposing it to a current of hydrogen gas. The oxide of mercury from calomel and water of potash, when exposed to the spectrum, was not changed in the most refrangible rays, but became red in the least refrangible, which must have been owing to the absorption of oxygen. The violet rays produced, upon moistened red oxide of mercury, the same effect as hydrogen gas.

Dr. Wollaston found, that guaiac, exposed to the violet rays, passed rapidly from yellow to green; and MM. Gay Lussac and Thenard applied to the same influence a gaseous mixture of hydrogen and chlorine, when explosion immediately took place. By placing small bits of card, coated with moist horn-silver, or little phials of those mixed gases, in the different parts of the spectrum, M. Berard verified the former observations of the chemical power acquiring a maximum in the violet ray, and existing even beyond it; but he also found, that by leaving the tests a sufficient time in the indigo and blue rays, a perceptible effect was produced upon them. He concentrated by a lens all that portion of the spectrum which extends from the green to the extreme boundary of the violet; and by another lens he collected the other half of the spectrum, comprehending the red. The latter formed the focus of a white light, so brilliant, that the eye could not endure it; yet in two hours it produced no sensible change on muriate of silver. On the contrary, the focus of the other half of the spectrum, whose light and heat were far less intense, blackened the muriate in ten minutes. The investigations of Delaroche enable us, in some measure, to reduce these dissimilar effects of light to a common principle. See CALORIC.

In Mr. Brande's late Bakerian lecture on the composition and analysis of coal and oil gases, this ingenious chemist shows, that the light produced by these, or by olefiant gas, even when concentrated so as to produce a sensible degree of heat, occasioned no change on the colour of muriate of silver, nor on a mixture of chlorine and hydrogen; while the light emitted by electrized charcoal speedily affects the muriate, causes these gases to unite rapidly, and sometimes with explosion. The concentrated light of the moon, like that of the gases, produced no change. He concludes with stating, that he found the photometer of Mr. Leslie ineffectual. He employed one filled with the vapour of ether (renewable from a column of that fluid), which he found to be more delicate.

The general facts, says Sir H. Davy, of the refraction and effects of the solar beam, offer an analogy to the agencies of electricity. In the voltaic circuit, the maximum of heat seems to be at the positive pole, where the power of combining with oxygen is given to bodies, and the agency of rendering bodies inflammable is exerted at the opposite surface; and similar chemical effects are produced by negative electricity, and by the most refrangible rays of the solar beam. In general, in nature, the effects of the solar rays are very compounded. Healthy vegetation depends upon the presence of the solar beams, or of light; and whilst the heat gives fluidity and mobility to the vegetable juices, chemical effects likewise are occasioned, oxygen is separated from them, and inflammable compounds formed. Plants deprived of light become white, and contain an excess of saccharine and aqueous particles; and flowers owe the variety of their hues to the influence of the solar beams. Even animals require the presence of the rays of the sun, and their colours seem materially to depend upon the chemical influence of these rays; a comparison between the polar and tropical animals, and between the parts of their bodies exposed and those not exposed to light, shows the correctness of this opinion.

The fact that a needle might be magnetized by exposing it to the violet ray of the solar spectrum, originally announced by Professor Morichini of Rome, verified by Professor Configliachi at Pavia, and M. Berard at Montpellier, has been lately demonstrated in a very able manner by Mrs. Mary Sommerville.

An equiangular prism of flint glass being placed in an aperture in a window-shutter, a sewing needle about an inch long, which had been previously ascertained to be devoid of magnetism by its attracting indifferently either pole of a magnetized needle, (also a sewing needle, thrust through a cork in which a glass cap was inserted, and suspended on the point of another needle) was exposed to the violet ray of the spectrum, thrown on a pannel, at the distance of about five feet. One half of the needle was covered with paper, as the author did not deem it likely that polarity would ensue from the action of the light, if the whole of the needle were uniformly exposed to its influence. In about two hours the needle became magnetized, the exposed end being found to be the north pole. The experiment having been many times repeated with the violet ray, and always with success, the blue and green rays of the spectrum were next ascertained to produce a similar effect, but in a less degree, and the indigo ray nearly in as great a degree as the violet. The yellow, orange, and red rays had no effect whatever on the needle exposed to them, even when the experiments were continued for three successive days; nor was any magnetism developed by the calorific rays, which showed that heat had no share in causing the results. It was found to be unnecessary to darken the room. Needles exposed half covered, with blue and green glass, or with blue and green ribands, the other half being covered with paper, became magnetized by being hung up in the sun for a day. The exposed end became the north pole. Bright sunshine is requisite. *Phil. Trans.* 1826.

III. *Polarization of Light.*

This new branch of optical science sprung from the ingenuity of Malus. It has been since cultivated chiefly by MM. Arago, Fresnel, and Biot in France, and by Dr. Brewster in this kingdom. I am happy to observe, that Mr. Herschel has lately entered the lists under very favourable auspices.

If a solar ray fall on the anterior surface of an unsilvered mirror plate, making an angle with it of 35° 25′, the ray will be reflected in a right line, so that the angle of reflection will be equal to the angle of incidence. In any point of its reflected path, receive it on another plane of similar glass, it will suffer in general a second partial reflection. But this reflection will vanish, or become null, if the second plate of glass form an angle of 35° 25′ with the first reflected ray, and at the same time be turned, so that the second reflection is made in a plane perpendicular to that in which the first reflection takes place. For the sake of illustration, suppose that the plane of incidence of the ray on the first glass coincides with the plane of the meridian, and that the reflected ray is vertical: Then, if we make the second inclined plate revolve, it will turn around the reflected ray, forming always with it the same angle; and the plane in which the second reflection takes place will necessarily be directed towards the different points of the horizon, in different azimuths. This being arranged, the following phenomena will be observed.

When the second plane of reflection is directed in the meridian, and consequently coincides with the first, the intensity of the light reflected by the second glass is at its maximum.

In proportion as the second plane, in its revolution, deviates from its parallelism with the first, the intensity of the reflected light will diminish.

Finally, when the second plane of reflection is placed in the prime vertical, that is, east and west, and consequently perpendicular to the first, the intensity of the reflection of light is absolutely null on the two surfaces of the second glass, and the ray is entirely transmitted.

Preserving the second plate at the same inclination to the horizon, if we continue to make it revolve beyond the quadrant now described, the phenomena will be reproduced in the inverse order; that is, the intensity of the light will increase, precisely as it diminished, and it will become equal, at equal distances from the east and west. Hence, when the second plane of reflection returns once more to the meridian, a second maximum of intensity equal to the first recurs.

From these experiments it appears, that the ray reflected by the first glass is not reflected by the second, under this incidence, when it is presented to it by its east and west sides; but that it is reflected, at least in part, when it is presented to the glass by any two others of its opposite sides. Now if we regard the ray as an infinitely rapid succession of a series of luminous particles, the faces of the ray are merely the successive faces of these particles. We must hence conclude, that these particles possess faces endowed with different physical properties, and that in the present circumstance, the first reflection has turned towards the same sides of space similar faces, or faces equally endowed at least with the property under consideration. It is this arrangement of its molecules which Malus named the *polarization* of light, assimilating the effect of the first glass to that of a magnetic bar, which would turn a series of magnetic needles, all in the same direction.

Hitherto we have supposed that the ray, whether incident or reflected, formed with the two mirror plates an angle of 35° 25′; for it is only under this angle that the phenomenon is complete. Without changing the inclination of the ray to the first plate, if we vary never so little the inclination of the second, the intensity of the reflected light is no longer null in any azimuth, but it becomes the feeblest possible in the prime vertical in which it was formerly null.

Similar phenomena may be produced, by substituting for the mirror glasses polished plates, formed for the greater part of transparent bodies. The two planes of reflection must always remain rectangular, but they must be presented to the luminous ray at different angles, according to their nature. Generally all polished surfaces have the property of thus polarizing, more or less completely, the light which they reflect under certain incidences; but there is for each of them a particular incidence, in which the polarization it impresses is most complete; and for a great many it amounts to the whole of the reflected light.

When a ray of light has received polarization in a certain direction, by the processes now described, it carries with it this property into space, preserving it without perceptible alteration, when we make it traverse perpendicularly a considerable mass of air, water, or any substance possessed of single refraction. But the substances which exercise double refraction, in general alter the polarization of the ray, and apparently in a sudden manner, and communicate to it a new polarization of the same nature, but in another direction. It is only in certain directions of the principal section, that the ray can escape this disturbing force.

In the Phil. Trans. for 1813, we have the first of a series of very interesting papers on polarized light by Dr. Brewster. This relates chiefly to some curious properties of agate. The plate of agate which he employed was bounded by parallel faces, was about the fifteenth of an inch thick, and was cut into a plane, perpendicular to the laminæ of which it was composed. When the image of a taper reflected from water at an angle of 52° 45′, so as to acquire the property discovered by Malus, was viewed through the plate of agate, so as to have its laminæ parallel to the plane of reflection, the flame appeared perfectly distinct; but when the agate was turned round, so that its laminæ became perpendicular to the plane of reflection, the light which formed the image of the taper suffered total reflection, and not one ray of it penetrated the agate. If a ray of light incident upon one plate of agate is received, after transmission, upon another plate of the same substance, having its laminæ parallel to those of the former, the light will find an easy passage through the second plate; but if the second plate has its laminæ perpendicular to those of the first, the light will be wholly reflected, and the luminous object will cease to be visible.

In a second important communication, in 1814, on the affections of light transmitted through crystallized bodies, after suggesting that the cultivation of this department of physics may enable us to explain the forms and structure of crystallized bodies, a prediction which he himself has since happily fulfilled, the Doctor states, that if the light polarized by agate is incident at a particular angle upon any transparent body, so that the plane of reflection is perpendicular to the laminæ of the agate, it will experience a total *refraction;* if it is transmitted through another plate of agate, having its laminæ at right angles to those of the plate by which the light is polarized, it will suffer total *reflection;* and if it is examined by a prism of Iceland crystal, turned round in the hand of the observer, it will vanish and reappear in every quadrant of its circular motion. The pencil of rays to which this remarkable property is communicated, is surrounded by a large mass of nebulous light, which extends about 7° 30′ in length, and 1° 7′ in breadth, on each side of the bright image. This nebulous light never vanished with the bright image which it enclosed, but was obviously affected with its different changes, increasing in magnitude as the bright image diminished, and diminishing as the bright image regained its lustre. Light polarized by the agate, or by any other means, is depolarized, or partly restored to its original state, by being transmitted in a particular direction through a plate of mica, or any other crystallized body.

the different forms of terrestrial matter. But we learn from scripture, that light pre-existed before this luminary, and that its subsequent condensation in his orb was a particular act of almighty power. The phosphorescence of minerals, buried since the origin of things in the bowels of the earth, coincides strictly with the Mosaic account of the creation. We shall therefore regard light, the first-born element of chaos, as an independent essence, universally distributed through the mineral, vegetable, and animal world, capable of being disengaged from its latent state by various natural and artificial operations. These are,

1. Friction.

To this head belong electrical light, and that evolved from the attrition of pieces of quartz, even under water.

2. Condensation and expansion. If atmospheric air or oxygen be suddenly compressed in a glass syringe, or if a glass ball, filled with the latter, be suddenly broke *in vacuo*, a flash of light is instantly perceived.

3. Heat. If air which has been heated up to 900° of Fahrenheit, and which is in itself

coal and phosphorus is shown, in the article COMBUSTION, to be merely the ignition of the solid particles of these bodies. At a certain elevation of temperature, about 800° Fahr. all solid bodies begin to give out light. The same effect is produced *in vacuo* by transmitting voltaic electricity through a metallic wire. To this section we must also refer the phosphorescence of minerals. This curious phenomenon seems to have been first described by Benvenuto Cellini, in his Treatise on Jewellery, published near the beginning of the 16th century. In the year 1663, Mr. Boyle observed, that diamond, when slightly heated, rubbed, or compressed, emitted a light almost equal to that of the glow-worm. The most complete account which we have of mineral phosphorescence, is that recently given by Dr. Brewster in the first volume of the Edinburgh Phil. Journal. His method of examination was ingenious and accurate. He never reduced the body to powder, but placed a fragment of it upon a thick mass of hot iron, or, in delicate experiments, introduced it into the bottom of a pistol barrel, heated a little below redness.

The following Table presents his Results:

Names of the Minerals.	Colour of the Minerals.	Colour and intensity of the Light.
Fluor spar,	Pink,	Green,
———	Purple,	Bluish,
———	Bluish-white,	Blue,
Compact fluor,	Yellowish,	Fine green,
Sandy fluor,	White,	White sparks,
Calcareous spar,	Yellow,	Yellow,
———	Transparent,	Yellowish,
Limestone from north of Ireland,	———	Yellowish-red,
Phosphate of lime,	Pink,	Yellow,
Arragonite,	Dirty white,	Reddish-yellow,
Carbonate of barytes,	Whitish,	Pale white,
Harmotome,	Colourless,	Reddish-yellow,
Dipyre,	White,	Specks of light,
Grammatite from Glentilt,	———	Yellow,
——— Cornwall,	———	Bluish,
Topaz, Aberdeenshire,	Blue,	Bluish,
———, Brazilian,	Yellow,	Faint yellowish,
———, New Holland,	White,	Bluish,
Rubellite,	Reddish,	Scarlet,
Sulphate of lime,	Yellowish,	Faint light,
——— barytes,	Yellow,	Pale light,
——— ———	Slate colour,	Pale light,
——— strontites,	Bluish,	A fragment shone pretty bright,
Sulphate of lead,	Transparent,	Faint and by fits,
Anhydrite,	Reddish,	Faint light,
Sodalite,	Dark green,	Pretty bright,
Bitter spar,	Yellowish,	Faint white,
Red silver ore,	Red,	Pretty bright, but flitting,
Barystrontianite,	White,	Faint,

[illegible]	Yellowish,	Bright white,
Sphene,	Yellow,	Bright white,
Tremolite,	Whitish,	Reddish-yellow,
Mica,	Greenish,	Whitish,
—— from Waygatz,	Black,	White specks,
—— ——	Brown,	Pretty bright,
Titanium sand,	Black,	Feeble specks,
Hornstone,	Grey,	Yellowish,
Table spar, Dognatska,	Whitish,	Yellowish,
Lapis lazuli,	Blue,	Faint,
Spodumene,	Greenish,	Faint,
Titanite,	Reddish,	Extremely faint,
Cyanite,	Yellowish-white,	Bluish,
Calamine,	Brown,	Faint,
Augite,	Green,	Pretty bright,
Petalite,	Reddish tinge,	Blue and very bright,
Asbestus, rigid	——	Pretty bright,
Datholite,	Transparent,	Bright,
Corundum,	Brown,	Bright,
Anatase,	Dark,	Reddish-yellow,
Tungstate of lime,	Yellowish-white,	Brilt. like a burning coal
Quartz,	The phosphorescence of these nine minerals was observed in the pistol barrel.	Very faint,
Amethyst,		Faint,
Obsidian,		Pretty bright; dirty blue
Mesotype from Auvergne,		Very faint,
Glassy actinolite,		Little specks,
Ruby silver,		Rather bright,
Muriate of silver,		Blue,
Carbonate of copper,		Very faint,
Green telesie,		Pale blue, & pretty brigh

The phosphorescence of anatase is entirely different from that of the other minerals. It appears suddenly like a flame, and is soon over. Dr. Brewster found, in opposition to what Mr. Wedgewood had stated, that exposure of green fluor spar to the heat of a common fire in a crucible for half an hour, entirely deprived it of phosphorescence. Though he placed one fragment for several days in the beams of a summer sun, and even exposed it to the bright light near the focus of a burning glass, he could not succeed in obtaining from it the slightest indication of phosphorescence. The light emitted in combustion belongs to the same head. The phosphoric light of minerals has the same properties as the direct light of the sun, according to Dr. Brewster.

4. Light emitted from bodies in consequence of the action of extraneous light. To this section we refer solar phosphori. The most powerful of these is the artificial compound of Canton. If we mix three parts of calcined oyster shells in powder, with one of flowers of sulphur, and ramming the mixture into a crucible, ignite it for half an hour, we shall find, that the bright parts will, on exposure to the sunbeam, or to the common day-light, or to an electrical explosion, acquire the faculty of shining in the dark, so as to illuminate the dial of a watch, and make its figures legil It will, indeed, after a while cease to shi but if we keep the powder in a well cor phial, a new exposure to the sunbeam will store the luminescence. Oyster shells, str fied with sulphur, in a crucible, and ignit yield a more powerful phosphorescent su stance than the powder. It also must be k in a close phial. When the electric discha is transmitted along the surfaces of cert bodies, or a little above them, a somewh durable phosphorescence is occasioned, whi probably belongs to this division.

Sulphate of barytes gives a bright green lig	
Carbonate,	ditto, less brilliant,
Acetate of potash,	brilliant green light,
Succinic acid,	ditto, more durable,
Loaf sugar,	ditto,
Selenite,	ditto, but transient,
Rock-crystal,	red, and then white,
Quartz,	dull white light,
Borax,	faint green light,
Boracic acid,	bright green light.

Mr. Skrimshire has given an extensiv catalogue of such substances in Nicholson' Journal, 8vo. volumes 15, 16, and 19. H shows that Canton's pyrophorus yields mor from Colly Weston, Northamptonshire, which effervesced with acids, gives a beautiful effect. When the explosion of a jar is taken *above* the centre of a piece some inches square, not only the part above the discharging rods is luminous, but the surface of the plate appears bespangled, with very minute brilliant points, to some distance from its centre; and when the points of the dischargers rest upon the surface of the slate, these minute spangles are detached and scattered about the table in a luminous state.

Dobereiner states, that a splendid phenomenon of light during crystallization was observed by M. Buchner, of Magonza, during the sublimation of benzoic acid, previously mixed with pulverized carbon. The sublimation was carried on in a tall glass cylinder upon a stove, and when it had well begun there appeared an uninterrupted succession of sparks, continuing for half an hour, and which ceased only when the cylinder was removed from the stove.

Dobereiner states, that he has reason to believe that those salts which contain no water of crystallization are especially powerful in producing light during their crystallization.—*Giorn. di Fisica*, vii. 470.

5. Light emitted during chemical changes, independent of heat, or in which no perceptible heat is developed. The substances from which such light is emitted are principally the following:—

Marine animals, both in a living state, and when deprived of life. As instances of the first may be mentioned, the shell-fish called *pholas*, the *medusa phosphorea*, and various other *mollusca*. When deprived of life, marine fishes, in general, seem to abound with this kind of light. The flesh of quadrupeds also evolves light. In the class of insects are many which emit light very copiously, particularly several species of *fulgora*, or lantern-fly; and of *lampyris*, or glow-worm; also the *scolopendra electrica*, and a species of crab called *cancer fulgens*. Rotten wood is well known to evolve light copiously, as well as peat-earth.

Dr. Hulme, in an elaborate dissertation on this light, published in the Phil. Trans. for 1790, establishes the following important propositions:—

1. The quantity of light emitted by dead animal substances is not in proportion to the degree of putrefaction in them, as is commonly supposed; but, on the contrary, the greater the putrescence, the less light is evolved. It would seem, that this element, endowed with pre-eminent elasticity, is the first to escape from the condensed state of combination in which it had been imprisoned by the powers of life; and is followed, after some time, by the fishes, from which it may be separated by a peculiar process, retained and rendered permanent for some time. A solution of 1 part of sulphate of magnesia in 8 of water, is the most convenient menstruum for extracting, retaining, and increasing the brilliancy of this light. Sulphate and muriate of soda, also, answer in a proper state of dilution with water. When any of the saline solutions is too concentrated, the light disappears, but instantly bursts forth again from absolute darkness, by dilution with water. I have frequently made this curious experiment with the light procured from whiting. Common water, lime water, fermented liquors, acids even very dilute, alkaline leys, and many other bodies, permanently extinguish this spontaneous light. Boiling water destroys it, but congelation merely suspends its exhibition; for it reappears on liquefaction. A gentle heat increases the vividness of the phenomenon, but lessens its duration.

We shall conclude the subject of light with the following important practical fact and practical problem.

1. Count Rumford has shown that the quantity of light emitted by a given portion of inflammable matter in combustion, is proportional in some high ratio to the elevation of temperature; and that a lamp having many wicks very near each other, so as mutually to increase their heat, burns with infinitely more brilliancy than the Argand's lamps in common use.

2. To measure the proportional intensities of two or more lights. Place them a few inches asunder, and at the distance of a few feet or yards from a screen of white paper, or a white wall. On holding a small card near the wall, two shadows will be projected on it, the darker one by the interception of the brighter light, and the lighter shadow by the interception of the duller light. Bring the fainter light nearer to the card, or remove the brighter one further from it, till both shadows acquire the same intensity; which the eye can judge of with great precision, particularly from the conterminous shadows at the angles. Measure now the distances of the two lights from the wall or screen, square them, and you have the ratio of illumination. Thus if an Argand flame, and a candle, stand at the distance of 10 feet, and 4 feet, respectively, when their shadows are equally deep, we have 10^2 and 4^2, or 100 and 16, or 6¼ and 1, for their relative quantities of light.

LIGURITE. A mineral occurring in oblique rhombic prisms of 140° and 40°, of an apple-green colour, and sometimes speckled externally. Lustre vitreous. Powder grayish-white. Spec. grav. 3.49. It contains, silica is reckoned superior to the chrysolite as a gem, in colour, hardness, and transparency.

LILALITE. The mineral Lepidolite.

LIMBILITE. A compact mineral of a honey-yellow colour; scratching glass, and melting into a compact black enamel. It is found in the form of irregular grains in the volcanic hill of Limbourg.—*Saussure.*

LIME. The oxide of calcium, one of the primitive earths. This subject has been already treated of under *Calcium.*

The most important applications of lime are to agriculture and building; on which subjects Sir H. Davy has given some excellent observations.

Quicklime in its pure state, whether in powder or dissolved in water, is injurious to plants. Grass is killed by watering it with lime water. But lime in its state of combination with carbonic acid is an useful ingredient in soils. Calcareous earth is found in the ashes of the greater number of plants; and exposed to the air, lime cannot long continue caustic, but soon becomes united to carbonic acid.

When lime, whether freshly burnt or slacked, is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water.

By this kind of operation, lime renders matter which was before comparatively inert, nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime.

Mild lime, powdered limestone, marles, or chalks, have no action of this kind upon vegetable matter: by their action they prevent the too rapid decomposition of substances already dissolved; but they have no tendency to form soluble matters.

It is obvious from these circumstances, that the operation of quicklime, and marle or chalk, depends upon principles altogether different. Quicklime, in the act of becoming mild, prepares soluble out of insoluble matter.

It is upon this circumstance that the operation of lime in the preparation for wheat crops depends; and its efficacy in fertilizing peats, and in bringing into a state of cultivation all soils abounding in hard roots or dry fibres, or inert vegetable matter.

The solution of the question, whether quicklime ought to be applied to a soil, depends upon the quantity of inert vegetable matter that it contains. The solution of the question, whether marle, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime,

contains much *soluble* vegetable manu application of quicklime should alw avoided, as it either tends to decomp soluble matters by uniting to their carb oxygen so as to become mild lime, or i bines with the soluble matters, and compounds having less attraction for than the pure vegetable substance.

The case is the same with respect t animal manures; but the operation of th is different in different cases, and depend the nature of the animal matter. Lime a kind of insoluble soap with oily matter then gradually decomposes them by sepa from them oxygen and carbon. It con likewise with the animal acids, and pro assists their decomposition by abstractin bonaceous matter from them combined oxygen; and, consequently, it must r them less nutritive. It tends to din likewise the nutritive powers of albumen the same causes; and always destroys, certain extent, the efficacy of animal man either by combining with certain of thei ments, or by giving to them new arr ments. Lime should never be applied animal manures, unless they are too ric for the purpose of preventing noxious effl It is injurious when mixed with any com dung, and tends to render the extractive ter insoluble.

In those cases in which fermentation is ful to produce nutriment from vegetable stances, lime is always efficacious, as tanners' bark.

The subject of the application of the m nesian limestone is one of great interest.

Magnesia has a much weaker attraction carbonic acid than lime, and will remain the state of caustic or calcined magnesia many months, though exposed to the And as long as any caustic lime remains, magnesia cannot be combined with carbo acid, for lime instantly attracts carbonic a from magnesia.

When a magnesian limestone is burnt, magnesia is deprived of carbonic acid mu sooner than the lime; and if there is not mu vegetable or animal matter in the soil to su ply, by its decomposition, carbonic acid, t magnesia will remain for a long while in t caustic state; and in this state acts as a pois to certain vegetables. And that more ma nesian lime may be used upon rich soi seems to be owing to the circumstance, th the decomposition of the manure in them su plies carbonic acid. But magnesia in its mi state, *i. e.* fully combined with carbonic aci seems to be always an useful constituent soils.

The Lizard Downs, which contain magne

sian earth, bear a short and green grass, which feeds sheep producing excellent mutton; and the cultivated parts are amongst the best corn lands in the county of Cornwall.

It is obvious, from what has been said, that lime from the magnesian limestone may be applied in large quantities to peats; and that where lands have been injured by the application of too large a quantity of magnesian lime, peat will be a proper and efficient remedy.

There are two modes in which lime acts as a cement: in its combination with water, and in its combination with carbonic acid.

When quicklime is rapidly made into a paste with water, it soon loses its softness, and the water and the lime form together a solid coherent mass, which consists of 1 part of water to 3 parts of lime. When hydrate of lime, whilst it is consolidating, is mixed with red oxide of iron, alumina, or silica, the mixture becomes harder, and more coherent than when lime alone is used; and it appears that this is owing to a certain degree of chemical attraction between hydrate of lime and these bodies; and they render it less liable to decompose by the action of the carbonic acid in the air, and less soluble in water.

The basis of all cements that are used for works which are to be *covered with water*, must be formed from hydrate of lime; and the lime made from impure limestones answers this purpose very well. Puzzolana is composed principally of silica, alumina, and oxide of iron; and it is used mixed with lime to form cements intended to be employed under water. Mr. Smeaton, in the construction of the Eddystone light-house, used a cement composed of equal parts by weight of slacked lime and puzzolana. Puzzolana is a decomposed lava. Tarras, which was formerly imported in considerable quantities from Holland, is a mere decomposed basalt: two parts of slacked lime and one part of tarras form the principal part of the mortar used in the great dykes of Holland. Substances which will answer all the ends of puzzolana and tarras are abundant in the British islands. An excellent red tarras may be procured in any quantities from the Giants' Causeway, in the north of Ireland; and decomposing basalt is abundant in many parts of Scotland, and in the northern districts of England in which coal is found.

Parker's cement, and cements of the same kind made at the alum works of Lord Dundas and Lord Mulgrave, are mixtures of calcined ferruginous, siliceous, and aluminous matter, with hydrate of lime. See CEMENT.

The cements which act by combining with carbonic acid, or the common mortars, are made by mixing together slacked lime and sand. These mortars at first solidify as hydrates, and are slowly converted into carbonate of lime by the action of the carbonic acid of the air. Mr. Tennant found that a mortar of this kind, in three years and a quarter, had regained 63 per cent. of the quantity of carbonic acid gas, which constitutes the definite proportion in carbonate of lime. The rubbish of mortar from houses owes its power to benefit lands principally to the carbonate of lime it contains, and the sand in it; and its state of cohesion renders it particularly fitted to improve clayey soils. The hardness of the mortar in very old buildings, depends upon the perfect conversion of all its parts into carbonate of lime. The purest limestones are the best adapted for making this kind of mortar: the magnesian limestones make excellent water cements, but act with too little energy upon carbonic acid gas to make good common mortar.

The Romans, according to Pliny, made their best mortar a year before it was used; so that it was partially combined with carbonic acid gas before it was employed.

In burning lime there are some particular precautions required for the different kinds of limestones. In general, one bushel of coal is sufficient to make four or five bushels of lime. The magnesian limestone requires less fuel than the common limestone. In all cases in which a limestone containing much aluminous or siliceous earth is burnt, great care should be taken to prevent the fire from becoming too intense; for such lime easily vitrifies, in consequence of the affinity of lime for silica and alumina. And as in some places there are no other limestones than such as contain other earths, it is important to attend to this circumstance. A moderately good lime may be made at a low red heat; but it will melt into a glass at a white heat. In limekilns for burning such lime, there should be always a damper.

In general, when limestones are not magnesian, their purity will be indicated by their loss of weight in burning; the more they lose, the larger is the quantity of calcareous matter they contain. The magnesian limestones contain more carbonic acid than the common limestones; and all of them lose more than half their weight by calcination.

The most important compounds of lime, are treated of under the different acids and combustibles.

LIME (CHLORIDE OF). The bleaching salt or bleaching powder of Mr. Tennant, called in commerce Oxymuriate of Lime. The following account of this important compound is extracted from a paper which I published on the subject in the Journal of Science and the Arts for July, 1822.

In the researches which I have made, at many different times, on the nature of the chloride of lime, I have generally sought to combine the information flowing from both synthesis and analysis; that is, I first converted a known portion of hydrate of lime into bleaching powder, and then subjected this to analysis. Among the results of experiments in my note-book of 1815, I find the following: 500 grains of unslacked quicklime, in fine powder, from Carrara marble, were exposed in a glass globe to a copious stream of chlorine (previously passed through a little cold water) for four days. The increase of weight was noted from time to time, and was found, at the end of that period, to be only 30 grains, which subsequent examination showed to be due to a little hydrated chloride; the few grains of water requisite having been derived from the great body of undried gas which had been transmitted. In May 1817, an experiment is recorded, in which 400 grains of a hydrate of Carrara lime, equivalent to 291.28 grains of dry lime, were exposed for two days to a stream of chlorine, washed in water of 50°, and refusing to absorb more gas, were found heavier by 270.5 grains. Supposing this augmentation to be chlorine, we shall have the composition of the powder, by the synthetic mode, as follows:

Chlorine,			40·34
Dry lime,	43·46	Hydrate,	59·66
Water,	16·20		
			100·00

This powder was analysed, by acting on a given weight of it with dilute muriatic acid, in a pear-shaped glass vessel. Care was taken to remove the whole disengaged chlorine, without letting any liquid escape. The lime was converted into carbonate, by a solution of carbonate of ammonia. The following are the results of two independent analytical experiments:

	1st Experiment.	2d Experiment.
Chlorine evolved,	40·60	39·40
Lime,	42·27	42·22
Water,	17·13	18·38
	100·00	100·00

I have reason to believe the second experiment the more correct of the two, and if the synthetic result be compared with it, we are led to infer that the very great body of undried chlorine passed over the lime had deposited two per cent. of water. By other experiments I satisfied myself, that dilute muriatic acid expelled nothing but pure chlorine; for the whole gas disengaged is absorbed on agitation with mercury. It does not appear possible to reconcile the above chlorides to a definite atomic constitution. The following experiments were made with much care last spring:

200 grains of the atomic protohydrate of pure lime were put into a glass globe, which was kept cool by immersion in a body of water at 50°. A stream of chlorine, after being washed in water of the same temperature in another glass globe, connected to the former by a long narrow glass tube, was passed over the calcareous hydrate. The globe with the lime was detached from the rest of the apparatus from time to time, that the process might be suspended as soon as the augmentation of weight ceased. This happened when the 200 grains of hydrate, containing 151.9 of lime, had absorbed 130 grains of chlorine. By one analytical experiment it was found, that dilute muriatic acid expelled from 50 grains of the chloride 20 grains of chlorine, or 40 per cent.; and by another, from 40 grains 16·25 of gas, which is 40.6 per cent. From the residuum of the first, 39.7 grains of carbonate of lime were obtained by carbonate of ammonia; from that of the second, 36.6 of ignited muriate of lime. The whole results are therefore as follows:

	Synthesis.	1st Analys.	2d Analys.	Mean.
Chlorine,	39·39	40·00	40·62	40·31
Lime,	46·00	44·74	46·07	45·40
Water,	14·60	15·26	13·31	14·28
	100·00	100·00	100·00	100·00

Though the heat generated by the action of the dilute acid has carried off in the analytical experiments a small portion of moisture with the chlorine, yet their accordance with the synthetic experiment is sufficiently good to confirm the general results. The above powder appears to have been a pure chloride, without any mixture of muriate. But it exhibits no atomic constitution in its proportions.

To 200 grains of that hydrate of lime, 30 grains of water being added, the powder was subjected to a stream of chlorine in the above way, till saturation took place. Its increase of weight was 150 grains. It ought to be remarked, that in this and the preceding experiment there was no appreciable pneumatic pressure employed, to aid the condensation of the chlorine. In the last case, we see that the addition of 30 grains of water has enabled the lime to absorb 20 grains more of chlorine, being altogether a quantity of gas nearly equal to that of the dry lime. Thus an atom of lime seems associated with 7-9ths of an atom of chlorine. Analysis by muriatic acid confirmed this composition. It gave,

Chlorine,	39·5 = 51.8 cubic inches.
Lime,	39.9
Water	20·6
	100.0

I next exposed some of this powder to heat in a small glass retort, connected with the hydro-pneumatic trough. Gas was very copiously disengaged, at a temperature far below ignition, the first portions coming off at the heat of boiling water; 100 measures of the collected gas being agitated with water at 50° F., 63 measures were absorbed, and the remaining 37 measures were oxygen, nearly pure. The smell of the first evolved gas was that of chlorine, after which the odour of euchlorine was perceived, and latterly the smell nearly ceased, as the product became oxygen. Having thus ascertained the general products, I now subjected to the same treatment 100 grains of the same powder (that last described), in a suitable apparatus; 30 cubic inches of gas were obtained from it, in a series of glass cylinders, standing over water at 50°. The first received portion was chlorine, nearly pure, but towards the end, when the heat approached or was at ignition, oxygen became the chief product. The residuary solid matter yielded to water a solution of muriate of lime, containing 30 grains of the dry salt, equivalent to about 15 of lime. But the chloride, both by synthesis and analysis, seemed to contain in 100 grains 51.8 cubic inches of chlorine, (corresponding to 25.9 of oxygen), with 39.9 of lime. Thus the volume of the evolved gas proves, independent of other considerations, that a considerable portion of chlorine came off, without dislodging the oxygen from the calcium; and as in subsequent experiments this volume was found to vary with the strength of the powder, and the mode of heating it, this method of analysis becomes altogether nugatory and delusive. The truth of this conclusion will still further appear on reflecting, that an uncertain portion of chlorine is condensed in the water of the trough, and that most probably a little euchlorine is formed at the period when the gaseous product passes from chlorine to oxygen. Thus, of the 39.9 grains of lime present in the chloride, 24.9 seem to have merely parted with their chlorine, while the other 15 lost their oxygen, equivalent to 12⅔ cubic inches, or 4·3 grains, and the remaining 10·7 of calcium combined with 19·3 of chlorine, to constitute the 30 grains of ignited muriate of lime. But 19·3 grains of chlorine form 25·3 cubic inches; hence 51·8 — 25·3 = 26·5 is the volume of chlorine disengaged by the heat, to which, if we add 12⅔ cubic inches of oxygen, the sum 39·16 is the bulk of gas that should have been received. The deficiency of 9.16 cubic inches is to be ascribed to absorption of chlorine (and perhaps of euchlorine), by the water of the pneumatic trough. In the above case, about one-half of the total chlorine came off in gas, and the other half combined with the basis of the lime, to the exclusion of its oxygen. I have observed, that the proportion of chlorine to that of oxygen given off by heat, increases, as one may naturally imagine, with the strength of the bleaching powder. When it is very weakly impregnated with chlorine, as is the case with some commercial samples, then the evolved gas consists in a great measure of oxygen.

Of the Manufacture of Bleaching Powder.

A great variety of apparatus has been at different times contrived for favouring the combination of chlorine with slacked lime, for the purposes of commerce. One of the most ingenious forms was that of a cylinder, or barrel, furnished with narrow wooden shelves within, and suspended on a hollow axis, by which the chlorine was admitted, and round which the barrel was made to revolve. By this mode of agitation, the lime-dust being exposed on the most extensive surface, was speedily impregnated with the gas to the requisite degree. Such a mechanism I saw at MM. Oberkamf and Widmer's celebrated *fabrique de toiles peintes*, at Joüy, in 1816. But this is a costly refinement, inadmissible on the largest scale of British manufacture. The simplest, and in my opinion the best, construction for subjecting lime powder to chlorine, is a large chamber eight or nine feet high, built of siliceous sandstone, having the joints of the masonry secured with a cement composed of pitch, rosin, and dry gypsum in equal parts. A door is fitted into it at one end, which can be made air-tight by stripes of cloth and clay lute. A window in each side enables the operator to judge how the impregnation goes on by the colour of the air, and also gives light for making the arrangements within at the commencement of the process. As water-lutes are incomparably superior to all others, where the pneumatic pressure is small, I would recommend a large valve, or door, on this principle, to be made in the roof, and two tunnels of considerable width at the bottom of each side wall. The three covers could be simultaneously lifted off by cords passing over a pulley, without the necessity of the workmen approaching the deleterious gas, when the apartment is to be opened. A great number of wooden shelves, or rather trays, eight or ten feet long, two feet broad, and one inch deep, are provided to receive the sifted slacked lime, containing generally about two atoms of lime to 3 of water. These shelves are piled one over another in the chamber, to the height of five or six feet, cross-bars below each keeping them about an inch asunder, that the gas may have free room to circulate over the surface of the calcareous hydrate.

The alembics for generating the chlorine, which are usually nearly spherical, are in some cases made entirely of lead, in others, of two hemispheres joined together in the middle, the upper hemisphere being lead, the under one cast-iron. The first kind of alembic is enclosed for two-thirds from its bottom in a leaden or iron case, the interval of two inches between the two being destined to receive steam from an adjoining boiler. Those which consist below of cast-iron have their bottom directly exposed to a very gentle fire; round the outer edge of the iron hemisphere a groove is cast, into which the under edge of the leaden hemisphere fits, the joint being rendered air-tight by Roman or patent cement*. In this leaden dome there are four apertures, each secured by a water-lute. The first opening is about ten or twelve inches square, and is shut with a leaden valve, with incurvated edges, that fit in the water-channel at the margin of the hole. It is destined for the admission of a workman to rectify any derangement in the apparatus of rotation, or to detach hard concretions of salt from the bottom. The second aperture is in the centre of the top. Here a tube of lead is fixed, which descends nearly to the bottom, and down through which the vertical axis passes, to whose lower end the cross bars of iron or of wood, sheathed with lead, are attached, by whose revolution the materials receive the proper agitation for mixing the dense manganese with the sulphuric acid and salt. The motion is communicated either by the hand of a workman applied from time to time to a winch at top, or it is given by connecting the axis with wheel work, impelled by a stream of water, or a steam-engine. The third opening admits the syphon-formed funnel, through which the sulphuric acid is introduced and the fourth is the orifice of the eduction pipe.

Manufacturers differ much from each other in the proportion of their materials for generating chlorine. In general, 10 cwt. of salt are mixed with from 10 to 14 cwt. of manganese; to which mixture, after its introduction into the alembic, from 12 to 14 of sulphuric acid are added in successive portions. That quantity of oil of vitriol must, however, be previously diluted with water, till its specific gravity becomes about 1.65. But, indeed, this dilution is seldom actually made, for the manufacturer of bleaching powder almost always prepares his own sulphuric acid for the purpose, and therefore carries its concentration no higher in the leaden boilers than the density of 1·65, which, from my table of sulphuric acid, indicates 1-4th of its weight of water, and therefore 1-3d more of such acid must be used.

The fourth aperture, I have said, admits the eduction pipe. This pipe is afterwards conveyed into a leaden chest, or cylinder, in which all the other eduction pipes also terminate. They are connected with it simply by water-lutes, having a hydrostatic pressure of 2 or 3 inches. In this general *diversorium* the chlorine is washed from adhering muriatic acid, by passing through a little water, in which each tube is immersed, and from this the gas is led off by a pretty large leaden tube, into the *combination room*. It usually enters in the top of the ceiling, whence it diffuses its heavy gas equally around.

Four days are required, at the ordinary rate of working, for making good marketable bleaching powder. A more rapid formation would merely endanger an elevation of temperature, productive of muriate of lime, at the expense of the bleaching quality. But skilful manufacturers use here an alternating process. They pile up, first of all, the wooden trays only in alternate shelves in each column. At the end of two days the distillation is intermitted, and the chamber is laid open. After two hours the workman enters, to introduce the alternate trays covered with fresh hydrate of lime, and at the same time rakes up thoroughly the half-formed chloride in the others. The door is then secured, and the chamber, after being filled for two days more with chlorine, is again opened, to allow the first set of trays to be removed, and to be replaced by others containing fresh hydrate, as before. Thus the process is conducted in regular alternation; thus, to my knowledge, very superior bleaching powder is manufactured, and thus the chlorine may be suffered to enter in a pretty uniform stream. But for this judicious plan, as the hydrate advances in impregnation, its faculty of absorption becoming diminished, it would be requisite to diminish proportionately the evolution of chlorine, or to allow the excess to escape, to the great loss of the proprietor, and, what is of more consequence, to the great detriment of the health of the workmen.

The manufacturer generally reckons on obtaining from one ton of rock-salt, employed as above, a ton and a half of good bleaching powder. But the following analysis of the operation will show, that he ought to obtain two tons.

Science has done only half her duty, when she describes the best apparatus and manipulations of a process. The *maximum* produce should be also demonstrated, in order to show the manufacturer the perfection which he should strive to reach, with the *minimum* expense of time, labour, and materials. For this end I instituted the following researches:—I first examined fresh commercial specimens of bleaching powder; 100 grains of these afforded from 20 to 28 grains of chlorine. This is the widest range of result, and it is undoubtedly considerable; the first being to the second, as 100 to 71. The first yielded, by saturation with muriatic acid, 82 grains of chloride of calcium, equivalent to about 41 of lime; it contained besides 26 *per cent.* of water, and a very little common muriate ready formed. On heating such powder in a glass apparatus, it yielded at first a little chlorine, and then oxygen tolerably pure. The bulk of chlorine did not exceed one-tenth of the whole gaseous product. Of the recently prepared powder of another manufacturer, 100 grains were found to give, by solution in acid, 23 grains of chlorine, and there remained, after evaporation and gentle ignition, 92 grains of muriate of lime, equivalent to about 46 of lime. Supposing this powder to have been nearly free from muriate, (and the manufacturers are anxious to prevent the deliquescent tendency which this introduces), we should have its composition as follows:—

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* A mixture of lime, clay, and oxide of iron, separately calcined, and reduced to a fine powder. It must be kept in close vessels, and mixed with the requisite water when used.

Chlorine,	23	3·5
Lime,	46	one atom 3·5 × 2 = 7·0
Water,	31	
	100	

This powder being well triturated with different quantities of water at 60°, yielded filtered solutions of the following densities at the same temperature:

		Sp. gr.
95 water	+ 5 bleaching powder,	1·0245
90	+ 10	1·0470
80	+ 20	1·0840

The powder left on the filter, even of the second experiment, contained a notable quantity of chlorine, so that the chloride is but sparingly soluble in water; nor could I ever observe that partition occasioned by water in the elements of the powder, of which Mr. Dalton and M. Welter speak. Of the solution 80 + 20, 500 grains, apparently corresponding to 100 grains of powder, gave off, by saturation with muriatic acid, 19 grains of chlorine, and the liquid, after evaporation and ignition, afforded 41·8 grains of chloride of calcium, equivalent to 21 of lime. Here 4 per cent. of chlorine seem to have remained in the undissolved calcareous powder, which indeed, on examination, yielded about that quantity. But the dissolved chloride of lime consisted of 19 chlorine to 21 lime; or of 4·5 atoms of the former, to almost exactly 5 (which is no atomic proportion) of the latter. The two-thirds of a grain of lime existing in lime water, in the five hundred grains of solution, will make no essential alteration on the statement. Now, the above bleaching powder must have contained very little muriate of lime, for it was not deliquescent. Being thus convinced, both by examining the pure chloride of my own preparation, as well as that of commerce, that no atomic relations are to be observed in its constitution, for reasons already assigned, I ceased to prosecute any more researches in that direction.

When we are desirous of learning minutely the proportion between the chloride and muriate of lime in bleaching powder, pure vinegar may be used as the saturating acid. Having thus expelled the chlorine, we evaporate to dryness, and ignite, when the acetate of lime will become carbonate, which will be separated from the original muriate by solution and filtration.

I have found, on trial, the method by carbonic acid to be exceedingly slow and unsatisfactory. After passing a current of this gas for a whole day through the chloride diffused in tepid water, I found the liquid still to possess the power of discharging the colour very readily from litmus paper. But the doctrine of equivalents furnishes a very elegant theorem with acetic acid, whose conveniency and accuracy in application I have verified by experiment. An apparently complex, and very important problem of practical chemistry, is thus brought within the reach of the ordinary manufacturer. Since common fermented vinegar is permitted by law to contain a portion of sulphuric acid, which avarice often leads the retailer to increase, we cannot employ it in the present research. But strong vinegar prepared from pyrolignous acid, such as that with which Messrs. Turnbull and Ramsay have long supplied the London market, being entirely free from sulphuric acid, is well adapted to our purpose. With such acid, contained in a poised phial, fully saturate a given weight (say 100 grains) of the bleaching powder, contained in a small glass matrass, applying a gentle heat at last, with inclination of the mouth of the vessel, to expel the adhering chlorine. Note the loss of weight due to the disengagement of the gas. (If carbonic acid be suspected to be present, the gas may be received over mercury.) Evaporate the solution, consisting of acetate and muriate of lime, to dryness, by a regulated heat, and note the weight of the mixed saline mass. Then calcine this, at a very gentle red heat, till the acetic acid be all decomposed. Note the loss of weight. We have now all the *data* requisite for determining the proportion of the constituents without solution, filtration, or precipitation by reagents.

PROBLEM I.—To find the lime originally associated with the chlorine, or at least *not* combined with muriatic acid, and therefore converted into an acetate. *Rule.*—Subtract from the above loss of weight its twenty-fifth part, the remainder is the quantity of lime taken up by the vinegar.

PROBLEM II.—To find the quantity of muriate of lime in the bleaching powder. *Rule.*—Multiply the above loss of weight by 1·7, the product is the quantity of carbonate of lime in the calcined powder, which being subtracted from the total weight of the residuum, the remainder is of course the muriate of lime. We know now the proportion of chlorine, lime, and muriate of lime, in 100 parts; the deficiency is the water existing in the bleaching powder. Thus, for example, I found 100 grains of a commercial chloride some time kept, to give off 21 grains of chlorine, by solution in dilute acetic acid. The solution was evaporated to dryness: of saline present, uncombined with muriatic acid. And 41·3 × 1·7 = 70·2 = the carbonate of lime in the residuary 84·3 grains of calcined salts. Therefore, 84·3 — 70·2 = 14·1 = muriate of lime. Now, by dissolving out the muriate of lime, and evaporating, I got 14 grains of it, and the remaining carbonate was 70·3 grains. Hence this powder consisted of chlorine 21, lime 39·65, muriate of lime 14, and water 25·35 = 100.

Sulphate of indigo, largely diluted with water, has been long used for valuing the blanching power of chloride of lime; and it affords, no doubt, a good comparative test, though from the variableness of indigo it can form no absolute standard. Thus I have found 3 parts of indigo, from the East Indies, to saturate as much bleaching powder as 4 parts of good Spanish indigo.

M. Welter's method is the following:— He prepared a solution of indigo in sulphuric acid, which he diluted, so that the indigo formed $\frac{1}{1000}$ of the whole. He satisfied himself by experiments, that 14 litres (854·4 cubic inches, or 3·7 wine gallons English) of chlorine, which weigh 651½ English grains, destroyed the colour of 164 litres of the above blue solution. He properly observes, that chlorine discolours more or less of the tincture, according to the manner of proceeding, that is, according as we pour the tincture on the aqueous chlorine, and as we operate at different times, with considerable intervals; if the aqueous chlorine or chloride solution be concentrated, we have the *minimum* of discoloration; if it be very weak, the *maximum*. He says, that solution of indigo, containing about $\frac{1}{1000}$ part, will give constant results to nearly $\frac{1}{40}$, and to greater nicety still, if we dilute the chlorine solution, so that it shall amount to nearly one-half the volume of the tincture which it can discolour; if we use the precaution to keep the solution of chlorine and the tincture in two separate vessels; and, finally, to pour both together into a third vessel. We should, at the same time, make a trial on another sample of chlorine whose strength is known, in order to judge accurately of the hue. On the whole, he considers that fourteen measures of gaseous chlorine can discolour 164 measures of the above indigo solution, being a ratio of nearly one to twelve. The advantage of the very dilute tincture obviously consists in this, that the excess of water condenses the chlorine separated from combination by the sulphuric acid, and confines its whole efficacy to the liquor; whereas, from concentrated solutions, much of it escapes into the atmosphere. Though I have made very numerous experiments with the indigo yellow by imperceptible shades. Hence an error of $\frac{1}{20}$ may readily be allowed, and even more, with ordinary observers.

When a mixture of sulphuric acid, common salt, and black oxide of manganese, are the ingredients used, as by the manufacturer of bleaching powder, the absolute proportions are,

1 atom mur. of soda,	7.5	29.70	100.0
1 atom perox. of mang.	5.5	21.78	73.3
2 at. oil of vit. 1.846	12.25	48.52	163.3
	25.25	100.00	

And the products ought to be—

Chlorine disengaged,	1 atom	4.5	17.82
Sulphate of soda,	1	9.0	35.64
Protosulphate of mang.	1	9.5	37.62
Water, . . .	2	2.25	8.92
		25.25	100.00

These proportions are, however, very different from those employed by many, nay, I believe, by all manufacturers; and they ought to be so, on account of the impurity of their oxide of manganese. Yet making allowance for this, I am afraid that many of them commit great errors in the relative quantities of their materials.

From the preceding computation, it is evident that 1 ton of salt with 1 ton of the above native oxide of manganese properly treated, would yield 0.59 of a ton of chlorine, which would impregnate 1.41 tons of slacked lime, producing 2 tons of bleaching powder, stronger than the average of the commercial specimens; or allowing for a little loss, which is unavoidable, would afford 2 tons of ordinary powder, with a little more slacked lime.

MM. Orfila, Leseure, Gerdy, and Hennelle, having to examine the body of an individual who was supposed to have been poisoned, and who had been dead for nearly a month, found the smell so insupportable that they were induced to try the application of the chloride of lime, as recommended by M. Labarraque. A solution of this substance was frequently sprinkled over the body, and produced quite a wonderful effect, for scarcely had they made a few aspersions, when the unpleasant odour was instantly destroyed, and the operation was proceeded in with comparative comfort.

Since the above experiment, a commission was appointed by the prefect of the police in Paris to clear out offensive drains, in the execution of which much benefit to the protection of the workmens' health was derived from chloride of lime. M. Gaultier de Claubry, after stating, as I have shown above, that carbonic acid expels the chlorine from the chloride of lime, proposes, as the best and most durable means of disinfecting the air in hospitals, &c. to expose a considerable surface of chloride of lime in the apartments of the sick, whence the chlorine will be slowly and steadily evolved by the carbonic acid of the atmosphere, without annoying the patients in the slightest degree. This is the only plan admissible with chlorine where the apartments cannot be emptied. Where they can, the method described under FUMIGATION is more energetic.

LIMESTONE. A genus of minerals, which Professor Jameson divides into the four following species: 1. Rhomb-spar; 2. Dolomite; 3. Limestone; and, 4. Arragonite. We shall consider the third species here. The same mineralogist divides limestone into twelve sub-species.

1. Foliated limestone; of which there are two kinds—calcareous spar, and foliated granular limestone. The first will be found in its alphabetical place in the Dictionary.

Granular foliated limestone. Colour white, of various shades; sometimes it is spotted. Massive, and in distinct angulo-granular concretions. Lustre glistening, between pearly and vitreous. Fracture foliated. Translucent. Hard as calcareous spar. Brittle. Sp. gr. Carrara marble 2.717. It generally phosphoresces when pounded, or when thrown on glowing coals. Infusible. Effervesces with acids. It is a pure carbonate of lime. It occurs in beds in granite, gneiss, &c. and rarely in secondary rocks. It is found in all the great ranges of primitive rocks in Europe. Parian marble, Pentelic marble, the Marmo Greco, the white marble of Luni, of Carrara, and of Mount Hymettus, the translucent white marble of statuaries, and flexible white marble, are the chief of the white marbles which the ancients used for sculpture and architecture. The red antique marble, Rosso antico of the Italians, and Egyptian of the ancients; the Verde antico, an indeterminate mixture of white marble and green serpentine; yellow antique marble; the antique Cipolin marble, marked with green-coloured zones, caused by talc or chlorite; and African breccia marble, are the principal coloured marbles of the ancients. The Scottish marbles are, the red and white Tiree, the former of which contains hornblende, sahlite, mica, and green earth; the Iona marble, harder than most others, consisting of limestone and tremolite, or occasionally a dolomite; the Skye marble; the Assynt in Sutherland, introduced into commerce by Mr. Joplin, of Gateshead. It is white and grey, of various shades. The Glentilt marble; the Balachulish; the Boyne; the Blairgowrie; and the Glenavon. Hitherto but few marbles of granular foliated limestone have been quarried in England. The *Mona marble* is not unlike *Verde antico*. The black marbles of Ireland, now so generally used by architects, are Lucullites. The Toreen in the county of Waterford, is a fine variegated sort; and a grey marble beautifully clouded with white, has been found near Kilcrump, in the same county. At Loughlougher, in Tipperary, a fine purple marble is found. The county of Kerry affords several variegated marbles. Of the continental marbles a good account is given by Professor Jameson, *Mineralogy*, vol. ii. p. 502.

2d Sub-species. Compact limestone; of which there are three kinds—common compact limestone, blue Vesuvian limestone, and roestone.

Common compact limestone has usually a gray colour, with coloured delineations. Massive, corroded, and in various extraneous shapes. Dull. Fracture fine splintery. Translucent on the edges. Softer than the preceding sub-species. Easily frangible. Streak grayish-white. Sp. gr. 2.6 to 2.7. It effervesces with acids, and burns into quicklime. It is a carbonate of lime, with variable and generally minute proportions of silica, alumina, iron, magnesia, and manganese. It occurs principally in secondary formations, along with sandstone, gypsum, and coal. Many animal petrifactions, and some vegetable, are found in it. It is rich in ores of lead and zinc; the English mines of the former metal being situated in limestone. When it is so hard as to take a polish, it is worked as a marble, under the name of shell, or *lumaccella* marble. It abounds in the sandstone and coal formations, both in Scotland and England; and in Ireland it is a very abundant mineral in all the districts where clay-slate and red sandstone occur. The Florentine marble, or *ruin marble*, is a compact limestone. Seen at a distance, slabs of this stone resemble drawings done in bistre.

2. Blue Vesuvian limestone. Colour dark bluish-grey, partly veined with white. Rolled and uneven on the surface. Fracture fine earthy. Opaque. Streak white. Semi-hard in a low degree. Feels heavy. Its constituents are, lime 58, carbonic acid 28.5, water somewhat ammoniacal 11, magnesia 0.5, oxide of iron 0.25, carbon 0.25, and silica 1.25.—*Klaproth*. It is found in loose masses among unaltered ejected minerals, in the neighbourhood of Vesuvius. In mosaic work, it is used for representing the sky.

3. Roestone. Colours brown and grey. Massive, and in distinct concretions, which are round granular. Dull. Opaque. Fracture of the mass round granular. Approaching to soft. Brittle. Sp. gr. 2.6 to 2.68. It dissolves with effervescence in acids. It occurs along with red sandstone and *lias* limestone. In England this rock is called Bath-stone, Ketton-stone, Portland-stone, and Oolite. It extends, with but little interruption, from Somersetshire to the banks of the Humber in Lincolnshire. It is used in architecture, but it is porous, and apt to moulder away, as is seen in the ornamental work of the Chapel of Henry VII.

3d, Sub-species. Chalk, which see.

4th, Agaric mineral, or Rock-milk. Colour white. In crusts or tuberose pieces. Dull. Composed of fine dusty particles. Soils strongly. Feels meagre. Adheres slightly to the tongue. Light, almost supernatant. It dissolves in muriatic acid with effervescence, being a pure carbonate of lime. It is found on the north side of Oxford, between the Isis and the Cherwell, and near Chipping Norton; as also in the fissures of limestone caves on the continent. It is formed by the attrition of water on limestone rocks.

5th Sub-species. Fibrous limestone; of which there are two kinds—satin-spar, or the common fibrous; and fibrous calc-sinter. *Satin-spar*. White of various shades. Massive, and in distinct fibrous concretions. Lustre glistening and pearly; fragments splintery; feebly translucent; as hard as calcareous spar; easily frangible; sp. gr. 2.7. Its constituents are, lime 50.8, carbonic acid 47.6? Stromeyer says it contains some per cents. of gypsum. It occurs in thin layers in clay-slate at Alstone-moor in Cumberland; in layers and veins in the middle district of Scotland, as in Fifeshire. It is sometimes cut into necklaces, &c.

Fibrous calc-sinter. It is used as marble, and the ancients formed it into unguent vases, the *alabaster-box* of Scripture. See CALK-SINTER.

6th Sub-species. Tufaceous limestone, or Calc-tuff. Colour gray. Massive, and in imitative shapes, enclosing leaves, bones, shells, &c. Dull. Fracture fine grained uneven. Opaque. Soft. Feels rough. Brittle. It is pure carbonate of lime. It occurs in beds, generally in the neighbourhood of rivers; near Starly-burn in Fifeshire, and other places. Used for lime.

7th Sub-species. Pisiform limestone, or Peastone. Colour yellowish-white. Massive, and in distinct concretions, which are round granular, composed of others which are very thin and concentric lamellar. In the centre there is a bubble of air, a grain of sand, or of some mineral matter. Dull. Fracture even. Opaque. Soft. Brittle. Sp. gr. 2·532. It is carbonate of lime. It is found in great masses in the vicinity of Carlsbad in Bohemia.

8th Sub-species. Slate-spar. Schieferspath. Colour white, of various shades. Massive, and in distinct curved lamellar concretions. Lustre glistening and pearly. Feebly translucent. Soft; between sectile and brittle. Feels rather greasy. Sp. gr. 2·63. Its constituents are, carbonate of lime, with three per cent. of oxide of manganese. It occurs in primitive limestone, in metalliferous beds, and in veins. It is found in Glentilt; in Assynt; in Cornwall; and near Granard in Ireland.

9th Sub-species. Aphrite, which see.

10th Sub-species. Lucullite; of which there are three kinds—compact, prismatic, and foliated.

§ 1. Compact is subdivided into the common or black marble; and the stinkstone.

a. The common compact. Colour grayish-black. Massive. Glimmering. Fracture fine grained uneven. Opaque. Semi-hard. Streak dark ash-gray. Brittle. Sp. gr. 3. When two pieces are rubbed together, a fetid urinous odour is exhaled, which is increased by breathing on them. It burns white, but forms a black-coloured mass with sulphuric acid. Its constituents are, lime 53.38, carbonic acid 41.5, carbon 0.75, magnesia and oxide of manganese 0.12, oxide of iron 0.25, silica 1.13, sulphur 0.25, muriates and sulphates of potash with water 2.62.—*John*. It is said to occur in beds in primitive and older secondary rocks. Hills of this mineral occur in the district of Assynt in Sutherland. Varieties of it are met with in Derbyshire; at Kilkenny; in the counties of Cork and Galway. The consul Lucullus admired it so much, as to give it his name. It is the *Nero antico* of the Italians.

b. Stinkstone or *Swinestone*. Colour white, of many shades, cream-yellow, gray, black, and brown. Massive, disseminated, and in distinct granular concretions. Dull. Fracture splintery. Opaque. Semi-hard. Streak grayish-white. Emits a fetid odour on friction. Brittle. Sp. gr. 2.7. The same chemical characters as the preceding. Its constituents are, 88 carbonate of lime, 4.13 silica, 3.1 alumina, 1.47 oxide of iron, 0.58 oxide of manganese, 0.30 carbon, 0.58 lime; sulphur, alkali, salt, water, 2.20.—*John*. It occurs in beds in secondary limestone, alternating occasionally with secondary gypsum and beds of clay. It is found in the vicinity of North-Berwick, resting on red sandstone, and in the parish of Kirbean in Galloway. It is employed for burning into lime.

§ 2. Prismatic lucullite. Colours black, gray, and brown. Massive, in balls, and in distinct concretions. External surface sometimes streaked. Internal lustre shining. Cleavage threefold. Translucent on the edges. Semi-hard. Streak gray coloured. Brittle. When rubbed it emits a strongly fetid urinous smell. Sp. gr. 2.67. When its powder is boiled in water, it gives out a transient hepatic odour. The water becomes slightly alkaline. It dissolves with effervescence in muriatic acid, leaving a charcoaly residuum. Its constituents resemble those of the preceding. It occurs in balls, in brown dolomite, at Building-hill, near Sunderland. It was at one time called *madreporite*.

§ 3. *Foliated or sparry lucullite*. Colours white, gray, and black. Massive, disseminated and crystallized in acute six-sided pyramids. Internal lustre glimmering. Fragments rhomboidal. Translucent. Semi-hard.

Brittle. Emits on friction a urinous smell. Sp. gr. 2.65. In other respects similar to the preceding. It is found in veins at Andreasberg in the Hartz.

11th Sub-species. Marle; of which there are two kinds, earthy and compact. *Earthy marle* has a gray colour, consists of fine dusty particles, feebly cohering; dull; soils slightly; is light; effervesces with acids; and emits a urinous smell when first dug up. Its constituents are, carbonate of lime, with a little alumina, silica, and bitumen. It occurs in beds in the secondary limestone and gypsum formations in Thuringia and Mansfeld. *Compact marle* has a gray colour; is massive, vesicular, or in flattened balls; contains petrifactions; dull; fracture earthy, but in the great slaty; yields to the nail; opaque; streak grayish-white; brittle; feels meagre; sp. gr. 2.4. It intumesces before the blowpipe, and melts into a greenish-black slag. It effervesces with acids. Its constituents are, carbonate of lime 50, silica 12, alumina 32, iron and oxide of manganese 2.—*Kirwan*. It occurs in beds in the secondary floetz limestone. It is frequent in the coal formations of Scotland and England.

12th Sub-species. Bituminous marle-slate. Colour grayish-black. Massive, and frequently with impressions of fishes and plants. Lustre glistening. Fracture slaty. Opaque. Shining streak. Soft. Sectile. Frangible. Sp. gr. 2·66. It is said to be carbonate of lime, with albumen, iron, and bitumen. It occurs in floetz limestone. It frequently contains cupreous minerals, petrified fishes, and fossil remains of cryptogamous plants. It abounds in the Hartzgebirge.—*Jameson*.

LIQUEFACTION. A chemical term, in some instances synonymous with the word *fusion*, in others with the word *deliquescence*, and in others again with the word *solution*.

LIQUIDITY. See CALORIC.

LIQUOR of FLINTS. See SILICA.

LITHIA. A new alkali. It was discovered by M. Arfredson, a young chemist of great merit, employed in the laboratory of M. Berzelius. It was found in a mineral from the mine of Uten in Sweden, called *petalite* by M. d'Andrada, who first distinguished it. Sir H. Davy demonstrated by voltaic electricity that the basis of this alkali is a metal, to which the name of *lithium* has been given.

Berzelius gives the following simple process as a test for lithia in minerals:—

A fragment of the mineral, the size of a pin's head, is to be heated with a small excess of soda, on a piece of platinum foil, by a blowpipe for a couple of minutes. The stone is decomposed, the soda liberates the lithia, and the excess of alkali preserving the whole fluid at this temperature, it spreads over the foil, and surrounds the decomposed mineral. That part of the platinum near to the fused alkali becomes of a dark colour, which is more intense, and spreads over a larger surface, in proportion as there is more lithia in the mineral. The oxidation of the platinum does not take place beneath the alkali, but only around it, where the metal is in contact with both air and lithia. Potash destroys the reaction of the platinum on the lithia, if the lithia be not redundant. The platinum resumes its metallic surface, after having been washed and heated.

Lithia may be obtained by fusing petalite with potash, dissolving the whole in muriatic acid, evaporating to dryness, and digesting in alcohol. The muriate of lithia being very soluble in that fluid, is taken up, while the other salts remain. By a second evaporation and solution in alcohol, it is obtained perfectly pure. The muriate is itself a salt very characteristic of the alkali. It may easily be decomposed by carbonate of silver; and the carbonate thus procured, when treated with lime, yields pure lithia. Dr. Gmelin fused petalite with five times its weight of nitrate of barytes, at a white heat, in a platinum crucible; digested the mass in muriatic acid; evaporated the solution to dryness; dissolved in water; separated the silica; and added rather more sulphuric acid than was equivalent to the barytes. The sulphate of barytes was got rid of by solution in water and filtration. The liquid was now concentrated by evaporation to expel the excess of muriatic acid. It was then supersaturated with carbonate of ammonia, which threw down the alumina and the oxide of iron. The filtered liquid was evaporated to dryness and the residue was ignited, to drive off the ammoniacal sulphate and muriate. The remainder was dissolved in water, and hydrosulphuret of ammonia was added to the solution to separate the manganese. Being now filtered, evaporated, and ignited, it was pure sulphate of lithia, from which he obtained the carbonate by adding acetate of barytes, and decomposing the resulting acetate of lithia by a red heat.

The first is the process of M. Vauquelin, and is vastly the simpler of the two.

M. Berzelius says that the most economical way of preparing lithia is to mix triphane or spodumene in powder with twice its weight of pulverized fluor spar and with sulphuric acid; then to heat the mixture till the fluoric acid with the silica is volatilized, and afterwards to separate the sulphate of lithia by solution.

M. Berzelius has found lithia to be a constant and essential element in the mineral waters of Bohemia. To detect and separate the lithia, he pours a solution of phosphate of soda into the mineral water, evaporates to dryness, and redissolves in cold water. The lithia is left in the state of an insoluble phosphate of lithia and soda.

The most complete account, which we have of lithia and its compounds, is that of Dr.

volume of *Gilbert's Annalen*.

Caustic lithia has a very sharp burning taste. It destroys the cuticle of the tongue like potash. It does not dissolve with great facility in water, and appears not to be much more soluble in hot than in cold water. In this respect it has an analogy with lime. Heat is evolved during its solution in water.

When exposed to the air it does not attract moisture, but absorbs carbonic acid, and becomes opaque. When exposed for an hour to a white heat in a covered platinum crucible its bulk does not appear to be diminished: but it has absorbed a quantity of carbonic acid.

It dissolves only in small quantity in alcohol of the specific gravity 0·85. When weak alcohol is added to an aqueous solution of lithia in a well stopped phial, no change takes place at first; but after some hours the lithia precipitates in the state of a white powder.

Lithia unites with sulphur according to Vauquelin. Sulphuret of lithia has a yellow colour, dissolves readily in water, and is decomposed by acids in the same way as the other alkaline sulphurets.

Phosphorus decomposes water with the help of caustic lithia. If we heat in a retort phosphorus with a solution of caustic lithia in water, phosphuretted hydrogen gas is disengaged, which catches fire when it comes into the air.

Neutral sulphate of lithia forms small prismatic crystals, having a good deal of lustre, sometimes constituting pretty long but narrow tables. When exposed to the air, they undergo only an insignificant efflorescence. This salt has a saline and scarcely bitter taste. It dissolves pretty readily in water, and melts when exposed to a temperature scarcely reaching a red heat.

Bisulphate of lithia dissolves in water with greater facility than the neutral salt. It forms six-sided tables, in which two of the faces, which are parallel to each other, far exceed the remaining ones in length. When exposed to a very high temperature, it gives out sulphurous acid and oxygen gas, and is converted into the neutral sulphate.

According to Arfredson, this bisalt dissolves with more difficulty in water than the neutral salt.

Phosphate of lithia.—Phosphoric acid when dropped into the solution of sulphate of lithia occasions no precipitate. But when the uncombined acid is saturated by ammonia, the phosphate of lithia is precipitated in the state of white flocks, which are insoluble in water.

When a drop of phosphoric acid is let fall into a very dilute solution of carbonate of lithia, no precipitate falls; but when the liquid is heated, the carbonic acid gas is disengaged,

There exists likewise a
It is obtained by dissolvi
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Nitrate of lithia form
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0·535 of a gramme of
lithia were, by means of
exposure to a strong heat,
of neutral sulphate of lithia
tity of sulphate contains 0·

Hence 0·535 of carbonat
posed of

Lithia,
Carbonic acid,

Or in the 100 parts,

Lithia,
Carbonic acid,

But the oxygen in

45·54 lithia is
54·46 carbonic acid

and 2 × 19·09 = 38·18, a
but little from 39·59.

The solution of carbonate
posed by lime and barytes w
luble in alcohol.

The platinum crucible in
of lithia has been exposed to
obvious indications of havin
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Muriate of lithia forms sma
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exposed in a platinum crucible,

covered, to an incipient white heat, it is fused into the chloride.

Chromate of lithia forms orange-yellow crystals, which appear to contain an excess of acid. They are oblique parallelopipeds with rhomboidal bases. Sometimes they exhibit a dendritical vegetation. This salt is soluble in water.

Oxalate of lithia.—A portion of carbonate of lithia was saturated with oxalic acid. The neutral salt crystallizes with difficulty. The crystals have the appearance of small opaque protuberances, and dissolve with facility in water. To the neutral solution of oxalate of lithia was added a quantity of oxalic acid, exactly equal to that already combined with the lithia. By evaporation, small transparent granular crystals of *binoxalate of lithia* were obtained. They appeared to dissolve with facility in water, though not to be so soluble as the neutral salt.

Neutral *tartrate of lithia* dissolves with facility in water, but does not crystallize, forming a white opaque mass, which does not deliquesce when exposed to the air. When tartaric acid is added to the solution of the neutral tartrate, no crystallizable bitartrate is formed; but perhaps we may deduce the existence of such a salt from the fact that when the solution is evaporated no crystals of tartaric acid make their appearance.

When the solution is evaporated to dryness, we obtain a white opaque mass, which exhibits no appearance of crystallization, and which dissolves with facility in water.

Acetate of lithia, when evaporated, forms a syrupy mass, which cracks on cooling; so that the glass looks as if it had burst. This matter deliquesces in the air, and sometimes, while attracting moisture, crystalline plates appear in it.

Tartrate of lithia and potash.—If the excess of the acid of bitartrate of potash be saturated by means of carbonate of lithia, we obtain by spontaneous evaporation, a salt which forms large crystals, having the shape of four-sided prisms terminated by parallelograms, with angles very nearly right. The diagonals of these terminal faces are distinctly marked, and the four triangles formed by means of them are streaked parallel to the edges of these faces. This salt dissolves readily in water, and has a saline and scarcely bitter taste. When exposed to the air, it effloresces slightly, and only on the surface.

Tartrate of lithia and soda.—Bitartrate of soda was neutralized by means of carbonate of lithia. By spontaneous evaporation, the liquid deposited long rectangular four-sided prisms, frequently terminated by an oblique face. This salt dissolves with facility in water, and effloresces only slightly, and on the surface. Its taste is purely saline, and not strong.

Muriate of platinum does not form a double salt with muriate of lithia. Potash and lithia, therefore, may be very well distinguished from each other by means of muriate of platinum.

From the preceding account of the salts of lithia, we see that they have many properties in common with the salts of soda. Like them they are neither precipitated by muriate of platinum, nor by tartaric acid. They may however be distinguished from the salts of soda by the following properties: When their concentrated solutions are mixed with a concentrated solution of carbonate of soda, a precipitate falls. They are likewise precipitated by phosphate of soda and phosphate of ammonia, when no uncombined acid is present.

In reference to analytical chemistry, it may be remarked, that lithia, potash, and soda, if they should exist in the same compound, may be separated in the following way:—

Lithia may be precipitated by means of phosphoric acid and an excess of caustic ammonia. The phosphate of lithia may be dissolved in acetic acid, and the phosphoric acid precipitated by means of acetate of lead, &c.

When lithia exists in a compound with potash, this last alkali may be precipitated by means of muriate of platinum.

From the results of the preceding experiments we see, says Dr. Gmelin, that if 10 be the equivalent number for oxygen, the equivalent number for lithium is 13·83, and for lithia 23·83; that for carbonate of lithia by calculation, 51·32; but according to the preceding experiment, 52·32, &c.

Placed in the voltaic circuit, Sir H. Davy showed, that it was decomposed with the same phenomena as the other alkalis. A portion of its carbonate being fused in a platinum capsule, the platinum was rendered positive, and a negative wire brought to the upper surface. The alkali decomposed with bright scintillations, and the reduced metal being separated, afterwards burned. The particles were very similar to sodium. A globule of quicksilver made negative, and brought into contact with the alkaline salt, soon became an amalgam of lithium, and had gained the power of acting on water, with the evolution of hydrogen, and formation of alkali.

M. Vauquelin concludes, from his experiments, that 100 parts of lithia contain 43·5 of oxygen, and 56·5 of metallic base; a quantity which, he observes, is greater than that of all the other alkalis. The Editors of the Ann. de Chimie remark, that, according to this estimate, the equivalent number of the metal is 12·97, of its oxide 22·97, of its dry sulphate 72·97, and of its crystallized sulphate 82·97. These numbers are adapted to the oxygen *radix* of 10. Dr. Gmelin's analysis of lithia makes its composition to be, by his own reduction,

Lithium,	58·05
Oxygen,	41·95
	100·00

His neutral sulphate consists of,

	Crystallised.	Dry.	
Sulphuric acid,	58·34	68·15	5·000
Lithia,	27·25	31·85	2·3367
Water,	14·41		

The prime equivalent of lithia inferred from this analysis approaches much nearer to M. Vauquelin's number than that deduced by Dr. Gmelin himself. If we convert this prime *ratio* into *per cent.* proportions, we shall have lithia a compound of

Lithium,	57·205	1·3367
Oxygen,	42·795	1·0000

From his analysis of the carbonate, the prime equivalent of lithia comes out, as nearly as possible, 2·3. We are therefore warranted to consider 1·3 as the prime of lithium, from the concurring experiments both of M. Vauquelin and Dr. Gmelin. I cannot see how the Doctor's own ingenious and accurate experiments on these two salts permitted him to make so erroneous an estimate of the equivalent of lithia, as 23·83, instead of 23¼ or 23.

LITHIC ACID. See Acid (Lithic).

LITHOMARGE. Stone-marrow, a mineral of which there are two kinds, the friable, and indurated.

Friable Lithomarge. Colour white, massive, and sometimes in crusts. Particles scaly, and feebly glimmering. Streak shining. Slightly cohering. Soils slightly. Feels rather greasy. Adheres to the tongue. Light. Phosphoresces in the dark. Its constituents are, silica 32, alumina 26.5, iron 21, muriate of soda 1.5, and water 17.0.—*Klaproth.* It occurs commonly in tin-stone veins.

Indurated Lithomarge. Colours yellowish and reddish white. Massive, and amygdaloidal. Dull. Fracture fine earthy. Opaque. Streak shining. Soft, sectile, and easily frangible. Adheres strongly to the tongue. Feels fine, and greasy. Sp. grav. 2.44. Infusible before the blowpipe: some varieties phosphoresce, and others, when moistened, afford an agreeable smell like that of nuts. Its constituents are, silica 45.25, alumina 36.5, oxide of iron 2.75, water 14, and a trace of potash.—*Klaproth.* It occurs in veins in porphyry, gneiss, &c. at Rochlitz in Saxony, and at Zöblitz.—*Jameson.*

LITMUS. See Archil.

LIVER OF SULPHUR. See Sulphur.

LIXIVIATION. The application of water to the fixed residues of bodies, for the purpose of extracting the saline part.

LIXIVIUM. A solution obtained by lixiviation.

LOADSTONE. See Ores of Iron.

LOAM. See Clay.

LOBOITE. A magnesian *idocrase* from Norway.

LOGWOOD. The tree which yields it is called by Linnæus, Hæmatoxylum campechianum.

Logwood is so heavy as to sink in water, hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black.

It yields its colour both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dye is a fine red, inclining a little to violet or purple, which is principally observable in its watery decoction. This, left to itself, becomes in time yellowish, and at length black. Acids turn it yellow; alkalis deepen its colour, and give it a purple or violet hue.

Stuffs would take only a slight and fading colour from decoction of logwood, if they were not previously prepared with alum and tartar. A little alum is added also to the bath. By these means they acquire a pretty good violet.

A blue colour may be obtained from logwood, by mixing verdigris with the bath, and dipping the cloth till it has acquired the proper shade.

The great consumption of logwood is for blacks, to which it gives a lustre and velvety cast, and for greys of certain shades. It is also of very extensive use for different compound colours, which it would be difficult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye.

Juice of logwood is frequently mixed with that of brasil, to render colours deeper; their proportion being varied according to the shade desired.

Logwood is used for dyeing silk violet.

For this, the silk must be scoured, alumed, and washed; because, without aluming, it would take only a reddish tinge, that would not stand wetting. To dye silk thus, it must be turned in a cold decoction of logwood till it has acquired the proper colour: if the decoction were used hot, the colour would be in stripes and uneven.

Bergmann has already observed, that a fine violet might be produced from logwood, by impregnating the silk with solution of tin. In fact, we may thus obtain, particularly by mixing logwood and brasil in various proportions, a great number of fine shades, more or less inclined to red, from lilac to violet. See Hematin.

LOMONITE, or Laumonite. Diprismatic Zeolite.

LUCULLITE. See Limestone, 10th species.

LUMACHELLA. See Limestone.

LUNA CORNEA. Muriate of silver. See Silver.

LUNAR CAUSTIC. Nitrate of silver, fused in a low heat. See Silver.

LUPULIN. M. Planche first ascertained that the three active ingredients of hop, the oil, resin, and bitter principle, reside in the brilliant yellow grains scattered over the calicinal scales of the cones which serve as their envelope. Dr. Ives, of New York, and MM. Payen and Chevalier, have since confirmed this position. This matter, when insulated, is of a golden yellow colour, in little grains, formed of an impalpable powder, without consistence, which attaches itself to the fingers and renders them rough. It has a penetrating aromatic odour. 200 grammes of this substance being put into a retort, with 300 grammes of distilled water, the mixture was subjected to distillation, and afforded water and oil of an odour entirely similar to that of this yellow matter; but much more penetrating, narcotic, and very acrid in the throat. This solution is soluble in a great measure in water. The total amount is about 2 *per cent.* of the yellow matter employed; and as this yellow matter is contained in hop, in the proportion of $\frac{1}{10}$, it follows that the hop contains about 2 parts in the thousand of essential oil.

The following ingredients were extracted by MM. Payen and Chevalier, from 200 parts of this yellow substance: 1, water; 2, essential oil; 3, carbonic acid; 4, sub-acetate of ammonia, generated in the distilled water after a few days; 4, traces of ozmazome; 6, traces of fatty matter; 7, gum; 8, malic acid; 9, malate of lime; 10, bitter matter 25 parts; 11, a well-characterized resin, 105 parts; 12, silica, 8 parts; 13, traces of carbonate, muriate, and sulphate of potash; 14, carbonate and phosphate of lime; 15, oxide of iron and traces of sulphur. The bitter matter introduced into the stomach destroys appetite.—*Journ. de Pharm.* 1822.

LUTE. The lutes with which the joinings of vessels are closed are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels.

When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flour-paste. In such cases also slips of wet bladder are very conveniently used.

When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quicklime slacked in the air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm. Of this lute, vessels may be formed hard enough to bear polishing on the wheel.

Lastly, when acid and corrosive vapours are to be contained, we must then have recourse to the lute called *fat lute*. This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken searce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime, and whites of eggs. These slips are to be fastened with packthread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

Fine porcelain clay, mixed with a solution of borax, is well adapted to iron vessels, the part received into an aperture being smeared with it.

LYCOPODIUM. The fine dust of lycopodium, or clubmoss, is properly the seeds of the plant, and when diffused or strewed in the air, it takes fire from a candle, and burns off like a flash of lightning. It is used in the London theatres.

LYDIAN STONE. Flinty slate.

LYTHRODES. See Scapolite.

M

MACERATION. The steeping of a body in a cold liquor.

MACLUREITE. Brucite.

MADDER, a substance very extensively employed in dyeing, is the root of the rubia tinctorum.

Although madder will grow both in a stiff clayey soil and in sand, it succeeds better in a moderately rich, soft, and somewhat sandy soil: it is cultivated in many of the provinces of France, in Alsace, Normandy, and Provence: the best of European growth is that which comes from Zealand.

The best roots are about the thickness of a goose quill, or at most of the little finger: they are semitransparent, and of a reddish colour;

they have a strong smell, and the bark is smooth.

Hellot ascribes the superiority of the madder which comes from the Levant to the circumstance of its having been dried in the open air.

The red colouring matter of madder may be dissolved in alcohol, and on evaporation a residuum of a deep red is left. Fixed alkali forms in this solution a violet, the sulphuric acid a fawn-coloured, and the sulphate of potash a fine red precipitate. Precipitates of various shades may be obtained by alum, nitre, chalk, sugar of lead, and the muriate of tin.

The quantity of aqueous chlorine required to destroy the colour of a decoction of madder is double what is necessary to destroy that of a decoction of an equal weight of brasil wood.

Wool would receive from madder only a perishable dye, if the colouring particles were not fixed by a base, which occasions them to combine with the stuff more intimately, and which in some measure defends them from the destructive influence of the air. For this purpose, the woollen stuffs are first boiled for two or three hours with alum and tartar, after which they are left to drain; they are then slightly wrung and put into a linen bag, and carried into a cool place, where they are suffered to remain for some days.

The quantities of alum and tartar, as well as their proportions, vary much in different manufactories. Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool; if the proportion of tartar be increased to a certain degree, instead of a red, a deep and durable cinnamon colour is produced, because, as we have seen, acids have a tendency to give a yellow tinge to the colouring particles of madder. Berthollet found, that by employing one-half tartar, the colour sensibly bordered more on the cinnamon than when the proportion was only one-fourth of the alum.

In dyeing with madder, the bath must not be permitted to boil, because that degree of heat would dissolve the fawn-coloured particles, which are less soluble than the red, and the colour would be different from that which we wish to obtain.

The quantity of madder which Mr. Poerner employs is only one-third of the weight of the wool, and Schaeffer advises only one-fourth.

If wool be boiled for two hours with one-fourth of sulphate of iron, then washed, and afterward put into cold water with one-fourth of madder, and then boiled for an hour, a coffee colour is produced. Bergmann adds, that if the wool have not been soaked, and if it be dyed with one part of sulphate of iron and two of madder, the brown obtained borders upon a red.

Berthollet employed a solution of tin in various ways, both in the preparation and in the maddering of cloth. He used different solutions of tin, and found that the tint was always more yellow or fawn-coloured, though sometimes brighter than that obtained by the common process.

Mr. Guhliche describes a process for dyeing silk with madder: For one pound of silk he orders a bath of four ounces of alum, and one ounce of a solution of tin; the liquor is to be left to settle, when it is to be decanted, and the silk carefully soaked in it, and left for twelve hours; and after this preparation, it is to be immersed in a bath containing half a pound of madder softened by boiling with an infusion of galls in white wine: this bath is to be kept moderately hot for an hour, after which it is to be made to boil for two minutes. When taken from the bath, the silk is to be washed in a stream of water, and dried in the sun. Mr. Guhliche compares the colour thus obtained, which is very permanent, to the Turkey red. If the galls be left out, the colour is clearer. A great degree of brightness may be communicated to the first of these, by afterward passing it through a bath of brasil wood, to which one ounce of solution of tin has been added: the colour thus obtained, he says, is very beautiful and durable.

The madder red of cotton is distinguished into two kinds: one is called simple madder red; the other, which is much brighter, is called Turkey or Adrianople red, because it comes from the Levant, and has seldom been equalled in brightness or durability by our artists.

Galls or sumach dispose thread and cotton to receive the madder colour, and the proper mordant is acetate of alumina.

The nitrate and muriate of iron as a mordant produces a better effect than the sulphate and acetate of the same metal; they afford a beautiful, well saturated violet colour.

The Adrianople red possesses a degree of brightness, which it is difficult for us to approach by any of the processes hitherto mentioned.

Some years ago, Mr. Papillon set up a dye-house for this red at Glasgow; and in 1790 the commissioners for manufactures in Scotland paid him a premium, for communicating his process to the late Prof. Black, on condition of its not being divulged for a certain term of years. The time being expired, it has been made public, and is as follows:—

Step. I.—For 100 lbs. of cotton, you must have 100 lb. of Alicant barilla, 20 lb. of pearl ashes, 100 lb. of quicklime.

The barilla is to be mixed with soft water in a deep tub, which has a small hole near the bottom of it, stopped at first with a peg. This hole is to be covered in the inside with a cloth supported by two bricks, that the ashes may be prevented from running out at it, or stopping it up, while the ley filters through it. Under this tub must be another, to receive the ley, and pure water is to be passed repeatedly through the first tub, to form leys of different strength, which are kept separate until their strength is examined. The strongest required for use must float an egg, and is called the ley of six degrees of the French hydrometer. The weaker are afterwards brought to this strength by passing them through fresh barilla; but a certain quantity of the weak, which is of two degrees of the above hydrometer, is reserved for dissolving the oil, the gum, and the salt, which are used in subsequent parts of the process. This ley of two degrees is called the weak barilla liquor; the other the strong.

Dissolve the pearl ashes in ten pails, of four gallons each, of soft water, and the lime in fourteen pails.

Let all the liquors stand till they become quite clear, and then mix ten pails of each.

Boil the cotton in this mixture five hours, then wash it in running water, and dry it.

Step. II. Bain bis, or gray steep.—Take a sufficient quantity (ten pails) of the strong barilla water in a tub, and mix with it two pailfuls of sheep's dung; then pour into it two quart bottles of sulphuric acid, one pound of gum-arabic, and one pound of sal ammoniac, both previously dissolved in a sufficient quantity of weak barilla water; and, lastly, twenty-five pounds of olive oil, previously dissolved, or well mixed with two pails of the weak barilla water.

The materials of this steep being well mixed, tread down the cotton into it until it is well soaked; let it steep twenty-four hours, then wring it hard, and dry it.

Steep it again twenty-four hours, and again wring and dry it.

Steep it a third time twenty-four hours, after which wring and dry it; and, lastly, wash it well, and dry it.

Step. III. The white steep.—This part of the process is precisely the same with the last in every particular, except that the sheep's dung is omitted in the composition of the steep.

Step. IV. Gall steep.—Boil twenty-five pounds of bruised galls in ten pails of river water, until four or five are boiled away; strain the liquor into a tub, and pour cold water on the galls in the strainer to wash out of them all their tincture.

As soon as the liquor is become milk-warm, dip your cotton, hank by hank, handling it carefully all the time, and let it steep twenty-four hours. Then wring it carefully and equally, and dry it well without washing.

Step. V. First alum steep.—Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil, skim the liquor well, add two pails of strong barilla water, and then let it cool until it is lukewarm.

Dip your cotton, and handle it hank by hank, and let it steep twenty-four hours; wring it equally, and dry it well without washing.

Step. VI. Second alum steep.—This is in every particular like the last; but after the cotton is dry, steep it six hours in the river, and then wash and dry it.

Step. VII. Dyeing steep.—The cotton is dyed by about ten pounds at once, for which take about two gallons and a half of bullocks' blood, mix it in the copper with twenty-eight pails of milk-warm water, stir it well, add twenty-five pounds of madder, and lastly, stir all well together. Then having beforehand put the cotton on sticks, dip it into the liquor, and move and turn it constantly one hour, during which gradually increase the heat until the liquor begins to boil at the end of the hour. Then sink the cotton, and boil it gently one hour longer; and lastly, wash it and dry it.

Take out so much of the boiling liquor, that what remains may produce a milk-warm heat with the fresh water with which the copper is again filled up, and then proceed to make up a dyeing liquor, as above, for the next ten pounds of cotton.

Step. VIII. The fixing steep.—Mix equal parts of the gray steep liquor and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture, and let it steep six hours: then wring it moderately and equally, and dry it without washing.

Step. IX. Brightening steep.—Ten pounds of white soap must be dissolved very carefully and completely in sixteen or eighteen pails of warm water: if any little bits of the soap remain undissolved, they will make spots in the cotton. Add four pails of strong barilla water, and stir it well. Sink the cotton in this liquor, keeping it down with cross sticks, and cover it up; boil it gently two hours, then wash it and dry it, and it is finished.

MADREPORES. A species of coral, the zoophyte of naturalists. They consist of carbonate of lime, and a little animal membranaceous substance.

MAGISTERY. Chemists formerly applied this term to almost all precipitates: at present it is applied only to a few, which have retained the name from habitual usage.

MAGISTERY OF BISMUTH. See BISMUTH.

MAGNESIA. One of the primitive earths, having a metallic basis, called magnesium. It has been found native in the state of hydrate.

Magnesia may be obtained, by pouring into a solution of its sulphate a solution of subcarbonate of soda, washing the precipitate, drying it, and exposing it to a red heat. It is usually procured in commerce by acting on magnesian limestone with the impure muriate of magnesia, or bittern of the sea-salt manufactories. The muriatic acid goes to the lime, forming a soluble salt, and leaves behind the magnesia of both the bittern and limestone. Or the bittern is decomposed by a crude subcarbonate of ammonia, obtained from the distillation of bones in iron cylinders. Muriate of ammonia and subcarbonate of magnesia result. The former is evaporated to dryness, mixed with chalk, and sublimed. Subcarbonate of ammonia is thus recovered, with which a new quantity of bittern may be decomposed; and thus in ceaseless repetition, forming an elegant and economical process. 100 parts of crystallized Epsom salt require for complete decomposition 56 of subcarbonate of potash, or 44 dry subcarbonate of soda, and yield 16 of pure magnesia after calcination.

Magnesia is a white, soft powder. Its sp. gr. is 2.3 by Kirwan. It renders the syrup of violets, and infusion of red cabbage, green, and reddens turmeric. It is infusible, except by the hydroxygen blowpipe. It has scarcely any taste, and no smell. It is nearly insoluble in water; but it absorbs a quantity of that liquid with the production of heat. And when it is thrown down from the sulphate by a caustic alkali, it is combined with water, constituting a hydrate, which, however, separates at a red heat. It contains about one-fourth its weight of water.

When magnesia is exposed to the air, it very slowly attracts carbonic acid. It combines with sulphur, forming a sulphuret.

The metallic basis, or magnesium, may be obtained in the state of amalgam with mercury, by electrization, as is described under BARIUM; but a much longer time is necessary. Sir H. Davy succeeded also in decomposing magnesia, by passing potassium in vapour through it, heated to whiteness, in a tube of platinum out of the contact of air. He then introduced a small quantity of mercury, and heated it gently for some time in the tube. An amalgam was obtained, which, by distillation, out of the contact of the atmosphere, afforded a dark grey metallic film, infusible at the point at which plate-glass softened, and which in the process of the distillation of the mercury rendered the glass black at its point of contact with it. This film burned with a red light when heated strongly, and became converted into a white powder, which had the character of magnesia. When a portion of magnesium was thrown into water, it sunk to the bottom, and effervesced slowly, becoming covered with a white powder. By adding a little muriatic acid to the water, the effervescence was violent. The metal rapidly disappeared, and the solution was found to contain magnesia. No direct experiments have as yet been made, to determine the proportions of the elements in magnesia; but from experiments made on the combination of this substance with sulphuric acid, assuming that they are in single proportions, Dr. Wollaston infers the equivalent of magnesia to be 2.46. Hence magnesium will be 1.46. M. Gay Lussac has lately experimented, with his characteristic accuracy, on the sulphate of magnesia, and finds it, when crystallized, a compound of dry sulphate of magnesia, 48.57

water, 51.43.

The equivalent number for the dry sulphate is 7.47129, whence that for magnesia is 2.47129, approaching very nearly to Dr. Wollaston's determination.

When magnesia is strongly heated in contact with 2 volumes of chlorine, this gas is absorbed, and 1 volume of oxygen is disengaged. Hence it is evident that there exists a combination of magnesium and chlorine, or a true chloride. The salt called muriate of magnesia is a compound of the chloride and water. When it is acted on by a strong heat, by far the greatest part of the chlorine unites to the hydrogen of the water, and rises in the form of muriatic acid gas; while the oxygen of the decomposed water combines with the magnesium to form magnesia.

Magnesia is often associated with lime in minerals, and their perfect separation becomes an interesting problem in analysis. M. Longchamp has published a valuable paper on the subject, in the 12th volume of the *Ann. de Chim. et de Phys.*

He considers subcarbonate of ammonia as the best reagent for separating the two earths. Care must be taken to filter the solution from the calcareous precipitate, shortly after the addition of the subcarbonate. If it stand 12 or 18 hours, subcarbonate of magnesia falls with the carbonate of lime. 100 parts of solution of pure muriate of lime gave, with subcarbonate of ammonia, 1.5475 parts of carbonate of lime: 100 of the same solution, previously mixed with muriate of magnesia in excess, yielded 1.5585 parts. Alkaline subcarbonates dissolve the subcarbonate of magnesia; but caustic potash precipitates magnesia perfectly, either with or without heat. He objects to the method of separating these earths, by first converting them into sulphates; first, on account of the great difficulty of driving off the water from the sulphates of magnesia; secondly, from the difficult solubility of heated and dry sulphate of magnesia in water; and thirdly, because the sulphate of magnesia is partly decomposed at very high heats.

Magnesia is chiefly used as an antacid, purgative, and lithontriptic in medicine. When incautiously used for a long time, it may produce very serious evils, of which a remarkable case is narrated by Mr. Brande, in the 1st volume of his Journal. A lady was recommended to take magnesia, in consequence of some very severe nephritic attacks, accompanied with the passage of gravel. She was desired to take a tea-spoonful every night; and Henry's calcined magnesia was preferred, as that always operated upon the bowels, and "carried itself off," which other magnesia did not, but, on the contrary, felt heavy and uneasy on the stomach. The dose was gradually increased to two tea-spoonfuls, in order to produce effect upon the bowels, which this quantity never failed to do. The symptoms for which it was ordered were soon removed, but the plan was persevered in for two years and a half, with little intermission; so that as the average weight of a tea-spoonful is at least 40 grains, and the average dose was a tea-spoonful and a half, it may be presumed that she took, during the above period, between 9 and 10 pounds troy. "In the course of the last autumn she became sensible of a tenderness in the left side, just above the groin, connected with a deep-seated tumour, obscurely to be felt upon pressure, and subject to attacks of constipation, with painful spasmodic action of the bowels, tenesmus, and a highly irritable state of stomach. These attacks recurred every two or three weeks, varying in violence, but requiring the use of active remedies. Several irregular lumps, of a soft light-brown substance, were voided, having the appearance of a large mass broken down, and when dry extremely friable. A part of each was subjected to analysis, and found to consist entirely of subcarbonate of magnesia, concreted by the mucus of the bowels, in the proportion of about 40 per cent. She was cured by the use of other purgatives." Another case is mentioned in which not only large quantities of a concretion of a similar description were voided, but upon examination after death, which took place perhaps six months after any magnesia had been taken, a collection supposed to be from four to six pounds was found imbedded in the head of the colon, which was of course much distended.

The most important magnesian salts are described under the acids.

MAGNESIA (HYDRATE OF). This mineral was found by Dr. Bruce of New York, in small veins in serpentine at Hoboken, in New Jersey. Colour white. Massive. Lustre pearly. Fracture foliated or radiated. Semitransparent in the mass; transparent in single folia. Soft, and somewhat elastic. Adheres slightly to the tongue. Sp. gr. 2.13. Soluble in acids. Its constituents are magnesia 70, water 30, which approaches to 1 prime equivalent of each.—*Jameson.*

MAGNESIAN LIMESTONE. See DOLOMITE.

MAGNESITE. Colour yellowish-grey, or yellowish-white, and marked with spots. It occurs massive, tuberose, reniform, and vesicular. Surface rough. Dull. Fracture conchoidal. Fragments rather sharp-edged. Opaque. Scratched by fluor spar, but it scratches calcareous spar. It adheres pretty strongly to the tongue. It feels rather meagre. Streak dull. Rather easily frangible. Sp. gr. 2.881. Infusible; but before the blowpipe it becomes so hard as to scratch glass. Its constituents are, 46 magnesia, 51 carbonic acid, 1 alumina, 0.25 ferruginous manganese, 0.16 lime, 1 water.—*Bucholz.* It is found at Hrubschitz in Moravia, in serpentine rocks.

MAGNETIC IRON ORE, AND PYRITES. See ORES OF IRON.

MALACHITE. See ORES OF COPPER.

MALACHOLITE. Sahlite.

MALATES AND MALIC ACID. See ACID (SORBIC).

MALLEABILITY. See DUCTILITY.

TABLE of the Malleability and Ductility of the Metals, from THENARD.

Ductile and Malleable in alphabetical order.	Brittle in alphabetical order.	Arranged nearly in the order of facility with which they pass through the wire plate.	Arranged nearly in the order of facility with which they pass through the laminating cylinders.
Cadmium	Antimony	Gold	Gold
Copper	Arsenic	Silver	Silver
Gold	Bismuth	Platinum	Copper
Iridium	Cerium	Iron	Tin
Iron	Chromium	Copper	Platinum
Lead	Cobalt	Zinc	Zinc
Mercury	Columbium	Tin	Iron
Nickel	Manganese	Lead	Nickel
Osmium	Molybdenum	Nickel	Palladium ?
Palladium	Rhodium	Palladium ?	Cadmium ?
Platinum	Tellurium	Cadmium ?	
Potassium	Tungsten		
Silver	Titanium		
Sodium	Uranium		
Tin			
Zinc			

MALT. Grain which has become sweet, from the conversion of its starch into sugar, by an incipient growth, or germination artificially induced, called malting. See Beer.

MALTHA. The mineral tallow of Kirwan, said to have been found on the coast of Finland. It resembles wax. Its spec. grav. is 0.77. It is white, brittle, stains paper like oil, melts with a moderate heat, and burns with a blue flame and much smoke. It dissolves readily in oil, and imperfectly in hot alcohol.

MANGANESE. A metal of a dull whitish colour when broken, but which soon grows dark by oxidation, from the action of the air. It is hard, brittle, though not pulverizable, and rough in its fracture; so difficultly fusible, that no heat yet exhibited has caused it to run into masses of any considerable magnitude. Its specific gravity is 8·0. When broken in pieces, it falls into a powder by spontaneous oxidation.

Manganese, heated in oxygen or chlorine, takes fire and forms an oxide or chloride. It has been thought difficult to decide on the oxides of manganese.

According to Sir H. Davy there are two oxides only, the olive and the black; Mr. Brande has three, the olive, dark red, and black; M. Thenard has four, the green, the white (in the state of hydrate), the chestnut-brown, and the black; Berzelius has five, the first grey, the second green, the third and fourth are not well defined, and the fifth is the black.

Two oxides, however, are well defined.

1. The first oxide may be obtained by dissolving common black manganese in sulphuric or nitric acid, adding a little sugar, and precipitating by solution of potash. A white powder is obtained, which being heated to redness out of the contact of air, becomes yellow, puce-coloured, and lastly red-brown. To be preserved, it should be washed in boiling water, previously freed from air, and then dried by distilling off the moisture in a retort filled with hydrogen. The dark olive oxide, when examined in large quantities, appears almost black; but when spread upon white paper, its olive tint is apparent. It takes fire when gently heated, increases in weight, and acquires a browner tint. It slowly absorbs oxygen from the air, even at common temperatures. It dissolves in acids without effervescence. The white powder obtained above is the hydrated protoxide. The different tints which it assumes by exposure to air are ingeniously supposed by Sir H. Davy to depend on the formation of variable quantities of the black-brown oxide, which probably retains the water contained in the white hydrate, and is hence deep puce-coloured.

2. The black *peroxide*. Its sp. gr. is 4. It does not combine with any of the acids. It yields oxygen when heated; and by intense ignition passes in a great measure into the protoxide. According to Sir H. Davy, the olive oxide consists of—

Manganesium,	-	79
Oxygen,	-	21

And the black oxide, of

Manganesium,	-	69
Oxygen, about	-	31

He considers the first as a deutoxide, whence the prime equivalent is inferred to be 7·533.

The olive oxide,	7·533 met.	+ 2. ox.
Or,	80.	+20.
The black oxide will be,	7·533	+ 3.
Or,	71·5	+28·
The compound of the first with water is a deutohydrate, or	7·533	+2·25w.

The olive oxide becomes green by the action of potash, whence Sir H. accounts for the mistakes of chemists relative to a green oxide. In this case there is a combination. See Cameleon Mineral.

By Dr. Thomson's experiments, with which my own, subsequently made in a different way, agree, the protoxide consists of 3·5 metal + 1 oxygen; the 2d of 3·5 + 2; whence the prime equivalent appears to be 3·5.

The chloride may be conveniently obtained by igniting the muriate of manganese. It thus appears as a pale pink-coloured substance, semitransparent, and in brilliant scales. It is a compound of 3·766 metal + 4·5 chlorine, from the experiments of Dr. John Davy.

Sir H. Davy is inclined to believe, that the olive oxide is the only one which enters into combination with vitrifiable substances.

The salts of manganese have been little studied. They are mostly soluble in water. Ferroprussiate of potash gives a white precipitate.

Hydrosulphuret,	-	white
Sulphuretted hydrogen,	-	0
Gallic acid,	-	0
Succinate and benzoate of am.		0

Concentrated sulphuric acid attacks manganese, at the same time that hydrogen gas is disengaged. If sulphuric acid be added, and drawn off by distillation several times from the black oxide, by a heat nearly approaching to ignition, in a glass vessel, it is found that oxygen gas is disengaged toward the end of each process, and part of the oxide is dissolved. The solution of the sulphate made from the metal itself is colourless. If it be made from the black oxide, it is a purplish-red; but this colour is destroyed by the light of the sun, and again restored by removing the solution into the dark.

Sulphurous acid dissolves the oxide, taking part of its oxygen, which converts it into sulphuric acid, thus forming a sulphate with the remaining oxide.

Nitric acid dissolves manganese with effervescence, and the escape of nitrous gas. A spongy, black, and friable matter remains, which is a carburet of iron. The solution does not afford crystals. The oxide is more readily soluble in nitrous acid.

Manganese is dissolved in the usual manner by muriatic acid. The solution of manganese in muriatic acid scarcely affords crystals; but a deliquescent saline mass by evaporation, which is soluble in alcohol.

In the dry way, the oxide of manganese combines with such earths and saline substances as are capable of undergoing fusion in a strong heat. These experiments are most advantageously performed by the blowpipe, which see.

This metal melts readily with most of the other metals, but rejects mercury. Gold and iron are rendered more fusible by a due addition of manganese; and the latter metal is rendered more ductile. Copper becomes less fusible, and is rendered whiter, but of a colour subject to tarnish.

The ore of manganese, which is known in Derbyshire by the name of *black wadd*, is remarkable for its spontaneous inflammation with oil. It is of a dark-brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterward suffered to cool for about an hour, and it be then loosely mixed or kneaded with two ounces of linseed oil; the whole, in something more than half an hour, becomes gradually hot, and at length bursts into flame. This effect wants explanation. It seems, in some measure, to resemble the inflammation of oils by the nitric acid.

Manganese was used chiefly by glass-makers and potters, but the important discovery of chlorine has greatly extended its utility. See BLEACHING.

MANNA. Several vegetables afford manna; but the ash, the larch, and the alhagi, afford it in the largest quantities.

The ash which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the most natural countries to this tree.

The manna flows naturally from the tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer.

Its smell is strong, and its taste sweetish and slightly nauseous: if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal.

Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords crystals of sugar.

Manna affords, by distillation, water, acid, oil, and ammonia: its coal affords fixed alkali.

This substance forms the basis of many purgative medicines.

MANURES. Animal and vegetable matters introduced into the soil, to accelerate vegetation, and increase the production of crops. They have been used since the earliest periods of agriculture. But the manner in which manures act, the best modes of applying them, and their relative value and durability, were little understood till the great chemist, who gave new lustre to the whole science, turned his mind to this, its darkest, but most important application. I conceive it will be doing a service to society, to aid the diffusion of the light springing from the invaluable researches of Sir H. Davy, by inserting the following short abstract from his Agricultural Chemistry.

The pores in the fibres of the roots of plants are so small, that it is with difficulty they can be discovered by the microscope; it is not therefore probable, that solid substances can pass into them from the soil. He tried an experiment on this subject: some impalpable powdered charcoal, procured by washing gunpowder, and dissipating the sulphur by heat, was placed in a phial containing pure water, in which a plant of peppermint was growing: the roots of the plant were pretty generally in contact with the charcoal. The experiment was made in the beginning of May 1805: the growth of the plant was very vigorous during a fortnight, when it was taken out of the phial; the roots were cut through in different parts; but no carbonaceous matter could be discovered in them, nor were the smallest fibrils blackened by charcoal, though this must have been the case had the charcoal been absorbed in a solid form.

No substance is more necessary to plants than carbonaceous matter; and if this cannot be introduced into the organs of plants except in a state of solution, there is every reason to suppose, that other substances less essential will be in the same case.

He found, by some experiments made in 1804, that plants introduced into strong fresh solutions of sugar, mucilage, tanning principle, jelly, and other substances, died; but that plants lived in the same solutions after they had fermented. At that time, he supposed that fermentation was necessary to prepare the food of plants; but he afterwards found, that the deleterious effect of the recent vegetable solutions, was owing to their being too concentrated; in consequence of which the vegetable organs were probably clogged with solid matter, and the transpiration by the leaves prevented. In the beginning of June, in the next year, he used solutions of the same substances, but so much diluted, that there was about only one two-hundredth part of solid vegetable or animal matter in the solutions. Plants of mint grew luxuriantly in all these solutions; but least so in that of the astringent matter. He watered some spots of grass in a garden with the different solutions separately, and a spot with common water: the grass watered with solutions of jelly, sugar, and mucilage, grew most vigorously; and that watered with the solution of the tanning principle grew better than that watered with common water.

Vegetable and animal substances deposited in the soil, as is shown by universal experience, are *consumed* during the process of vegetation; and they can only nourish the plant by affording solid matters capable of being dissolved by water, or gaseous substances capable of being absorbed by the fluids in the leaves of vegetables; but such parts of them as are rendered gaseous, and that pass into the atmosphere, must produce a comparatively small effect, for gases soon become diffused through the mass of the surrounding air. The great object in the application of manure should be to make it afford as much soluble matter as possible to the roots of the plant; and that in a slow and gradual manner, so that it may be entirely consumed in forming its sap and organized parts.

Whenever manures consist principally of matter soluble in water, it is evident that their fermentation or putrefaction should be prevented as much as possible; and the only cases in which these processes can be useful, are when the manure consists principally of vegetable or animal *fibre*. The circumstances necessary for the putrefaction of animal substances, are similar to those required for the fermentation of vegetable substances; a temperature above the freezing point, the presence of water, and the presence of oxygen, at least in the first stage of the process.

To prevent manures from decomposing, they should be preserved dry, defended from the contact of air, and kept as cool as possible.

All green *succulent plants* contain saccharine or mucilaginous matter, with woody fibre, and readily ferment. They cannot, therefore, if intended for manure, be used too soon after their death.

Rape cake, which is used with great success as a manure, contains a large quantity of mucilage, some albuminous matter, and a small quantity of oil. This manure should be used recent, and kept as dry as possible before it is applied. It forms an excellent dressing for turnip crops; and is most economically applied by being thrown into the soil at the same time with the seed. Whoever wishes to see this practice in its highest degree of perfection, should attend Mr. Coke's annual sheep-shearing, at Holkham.

Sea-weeds, consisting of different species of fuci, algæ, and confervæ, are much used as a manure on the sea-coasts of Britain and Ireland. This manure is transient in its effects, and does not last for more than a single crop, which is easily accounted for from the large quantity of water, or the elements of water, it contains. It decays without producing heat when exposed to the atmosphere, and seems, as it were, to melt down and dissolve away. Sir H. has seen large heaps entirely destroyed in less than two years, nothing remaining but a little black fibrous matter.

The best farmers in the west of England use it as fresh as it can be procured; and the practical results of this mode of applying it are exactly conformable to the theory of its operation.

When straw is made to ferment, it becomes a more manageable manure; but there is likewise, on the whole, a great loss of nutritive matter. More manure is perhaps supplied for a single crop; but the land is less improved than it would be, supposing the whole of the vegetable matter could be finely divided and mixed with the soil.

Lord Meadowbank states, that one part of dung is sufficient to bring three or four parts of peat into a state in which it is fitted to be applied to land; but of course the quantity must vary according to the nature of the dung and of the peat. In cases in which some living vegetables are mixed with the peat, the fermentation will be more readily effected.

Manures, from animal substances, in general, require no *chemical* preparation to fit them for the soil. The great object of the farmer is to blend them with the earthy constituents in a proper state of division, and to prevent their too rapid decomposition.

Fish forms a powerful manure, in whatever state it is applied; but it cannot be ploughed in too fresh, though the quantity should be limited. Mr. Young records an experiment, in which herrings spread over a field, and ploughed in for wheat, produced so rank a crop, that it was entirely laid before harvest.

Bones are much used as a manure in the neighbourhood of London. After being broken, and boiled for grease, they are sold to the farmer. The more divided they are, the more powerful are their effects. The expense of grinding them in a mill would probably be repaid by the increase of their fertilizing powers; and in the state of powder they might be used in the drill husbandry, and delivered with the seed, in the same manner as rape-cake.

During the putrefaction of urine, the greatest part of the soluble animal matter that it contains is destroyed; it should consequently be used as fresh as possible; but if not mixed with solid matter, it should be diluted with water, as when pure it contains too large a quantity of animal matter to form a proper fluid nourishment for absorption by the roots of plants.

Putrid urine abounds in ammoniacal salts; and, though less active than fresh urine, is a very powerful manure.

Amongst excrementitious solid substances used as manures, one of the most powerful is the *dung* of *birds* that feed on *animal* food, particularly the dung of sea-birds. The *guano*, which is used to a great extent in South America, and which is the manure that fertilizes the sterile plains of Peru, is a production of this kind.

It contains a fourth part of its weight of uric acid, partly saturated with ammonia and partly with potash; some phosphoric acid combined with the bases, and likewise with lime. Small quantities of sulphate and muriate of potash, a little fatty matter, and some quartzose sand.

Night-soil, it is well known, is a very powerful manure, and very liable to decompose.

The disagreeable smell of night-soil may be destroyed by mixing it with quicklime; and if exposed to the atmosphere in thin layers strewed over with quicklime in fine weather, it speedily dries, is easily pulverized, and in this state may be used in the same manner as rape-cake, and delivered into the furrow with the seed.

The Chinese, who have more practical knowledge of the use and application of manure than any other people existing, mix their night-soil with one-third of its weight of a fat marle, make it into cakes, and dry it by exposure to the sun. These cakes, we are informed by the French missionaries, have no disagreeable smell, and form a common article of commerce of the empire.

After night-soil, *pigeons' dung* comes next in order as to fertilizing power.

If the pure dung of cattle is to be used as manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment except in the soil; or if suffered to ferment, it should be only in a very slight degree. The grass in the neighbourhood of recently voided dung is always coarse and dark-green: some persons have attributed this to a noxious quality in unfermenting dung; but it seems to be rather the result of an excess of food furnished to the plants.

A slight incipient fermentation is undoubtedly of use in the dunghill; for by means of it a disposition is brought on in the woody fibre to decay and dissolve, when it is carried to the land, or ploughed into the soil; and woody fibre is always in great excess in the refuse of the farm.

Too great a degree of fermentation is, however, very prejudicial to the composite manure in the dunghill; it is better that there should be no fermentation at all before the manure is used, than that it should be carried too far.

Within the last seven years Mr. Coke has entirely given up the system formerly adopted on his farm, of applying fermented dung; and he has found, that his crops have been since as good as they ever were, and that his manure goes nearly twice as far.

In cases when farm-yard dung cannot be immediately applied to crops, the destructive fermentation of it should be prevented very carefully.

The surface should be defended as much as possible from the oxygen of the atmosphere; a compact marle, or a tenacious clay, offers the best protection against the air; and before the dung is covered over, or, as it were, sealed up, it should be dried as much as possible. If the dung is found at any time to heat strongly, it should be turned over, and cooled by exposure to air.

If a thermometer plunged into the dung does not rise to above 100 degrees of Fahr. there is little danger of much aëriform matter flying off. If the temperature is higher, the dung should be immediately spread abroad.

When a piece of paper moistened in muriatic acid, held over the steams arising from a dunghill, gives dense fumes, it is a certain test that the decomposition is going too far, for this indicates that volatile alkali is disengaged.

When dung is to be preserved for any time, the situation in which it is kept is of importance. It should, if possible, be defended from the sun. To preserve it under sheds would be of great use; or to make the site of a dunghill on the north side of a wall.

Soot, which is principally formed from the combustion of pit-coal, or coal generally, contains likewise substances derived from animal matters. This is a very powerful manure.

It is well fitted to be used in the dry state, thrown into the ground with the seed, and requires no preparation. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble.

"The doctrine of the proper application of manures from organized substances," says Sir H. Davy, "offers an illustration of an important part of the economy of nature, and of the happy order in which it is arranged.

"The death and decay of animal substances tend to resolve organized forms into chemical constituents; and the pernicious effluvia disengaged in the process, seem to point out the propriety of burying them in the soil, where they are fitted to become the food of vegetables. The fermentation and putrefaction of organized substances in the free atmosphere are noxious processes; beneath the surface of the ground they are salutary operations. In this case the food of plants is prepared where it can be used; and that which would offend the senses and injure the health, if exposed, is converted by gradual processes into forms of beauty and of usefulness; the fetid gas is rendered a constituent of the aroma of the flower, and what might be poison, becomes nourishment to animals and to man."

MARBLE. See Limestone.

MARCASITE. See Pyrites.

MARECANITE. Obsidian, in the form of little grains, like peas, pearly-white, consisting of very thin concentric layers, found in Marekan in the gulf of Kamschatka.

MARGARIC ACID. See Acid (Margaric).

MARGARITE. A mineral, in mass, of a grayish-white colour, and in small crystalline laminæ, intersecting each other in every direction. It is like silvery mica. It occurs in the Tyrol.

MARINE ACID. Acid (Muriatic).

MARLE. See Limestone.

MARMOR METALLICUM. Native sulphate of barytes.

MARROW. The animal fat found in the cavities of long bones.

MARS. The mythological and alchemistical name of iron.

MARTIAL ETHIOPS. Protoxide of Iron.

MARTIAL SALTS. Salts of Iron.

MASSICOT. Yellow oxide of lead. See Lead.

MASTIC. A resinous substance in the form of tears, of a very pale yellow colour, and farinaceous appearance, having little smell, and a bitter astringent taste. It flows naturally from the tree, but its produce is accelerated by incisions. The lesser turpentine tree and the lentiscus afford the mastic of commerce.

No volatile oil is obtained from this substance when distilled with water. Pure alcohol and oil of turpentine dissolve it; water scarcely acts upon it; though by mastication it becomes soft and tough, like wax. When chewed a little while, however, it is white, opaque, and brittle, so as not to be softened again by chewing. The part insoluble in alcohol much resembles in its properties caoutchouc. It is used in fumigations, in the composition of varnishes, and is supposed to strengthen the gums.

MATRASS. See Laboratory.

MATRIX. The earthy or stony matter which accompanies ores, or envelopes them in the earth.

MEADOW-ORE. Conchoidal Bog Iron-ore.

MEASURES. The English measures of capacity are according to the following table:

One gallon, wine measure, is equal to	four quarts.
One quart, . .	two pints.
One pint, . .	28·875 cubic inches.

The pint is subdivided by chemists and apothecaries into 16 ounces.

The gallon, quart, and pint, ale measure, are to the measures of the same denominations, wine measure, respectively, as 282 to 231. See Acid (Muriatic), and Appendix.

The Paris foot is equal to 12.789 English inches, or to the English foot as 114 to 107. For measures of weight, &c., see Balance.

MECONIC ACID. See Acid (Meconic).

MEDULLIN. The name given by Dr. John to the porous pith of the sun-flower. It is soluble in nitric acid, but insoluble in water, ether, alcohol, and oils; is void of taste and smell; and on distillation it affords ammonia, leaving a charcoal of a metallic or bronze appearance.

MEERSCHAUM. Keffekil of Kirwan. Colours yellowish and grayish-white. Massive. Dull. Fracture fine earthy. Fragments angular. Opaque. Streak slightly shining. Does not soil. Very soft, sectile, but rather difficultly frangible. Adheres strongly to the tongue. Feels rather greasy. Sp. gr. 1.2 to 1.6. Before the blowpipe, it melts on the edges into a white enamel. Its constituents are, silica 41·5, magnesia 18·25, lime 0·50, water and carbonic acid 39.—*Klaproth*. It occurs in the veins in the serpentine of Cornwall. When first dug, it is soft, greasy, and lathers like soap. Hence the Tartars use it for washing clothes. In Turkey it is made into tobacco pipes, from meerschaum dug in Natolia, and near Thebes. See Jameson's Mineralogy for an entertaining account of the manufacture.

MEIONITE. Prismato-pyramidal felspar. Colour grayish-white. Massive, but more frequently crystallized. The primitive form is a pyramid, in which the angles are 136° 22′, 63° 22′. Its secondary forms are rectangular four-sided prisms, variously acuminated or truncated. The crystals are small, smooth, and splendent. Lustre vitreous. Cleavage double rectangular. Transparent. Harder than common felspar, but softer than quartz. Easily frangible. Sp. gr. 2·6. Easily fusible before the blowpipe with intumescence. It occurs along with ceylanite and nepheline, in granular limestone, at Monte Somma near Naples.

MELANITE. Colour velvet-black. In roundish grains, but more frequently crystallized in a rhomboidal dodecahedron, truncated on all the edges. Surface of the grains rough and uneven; that of the crystals shining. Fracture flat conchoidal. Opaque. As hard as quartz. Rather easily frangible. Sp. gr. 3·73. Its constituents are, silica 35·5, alumina 6, lime 32·5, oxide of iron 25·25, oxide of manganese 0·4, loss 0·35. It is found in a rock at Frescati near Rome, and in the basalt of Bohemia.

MELASSES. The black empyreumatic syrup which drains from raw sugar.

MELILITE. A mineral, in small square prisms. Internally of a honey-yellow colour; externally coated yellow by oxide of iron. It gives sparks with steel. Found at Capo di Bove near Rome.

MELLATES. Compounds of mellitic acid with the salifiable bases.

MELLITE, OR HONEY-STONE. Colour honey yellow. Rarely massive. Crystallized. Its primitive figure is a pyramid of 118° 4′, and 93° 22′. The secondary figures are; the primitive, truncated on the apices; on the apices and angles of the common base; and the angles on the common base bevelled. Externally smooth and splendent. Cleavage pyramidal. Fracture perfect conchoidal. Semi-transparent. Refracts double, in the direction of the pyramidal plane. Harder than gypsum, but softer than calcareous spar. Brittle. Sp. gr. 1·4 to 1·6. Before the blowpipe it becomes white and opaque, with black spots, and is at length reduced to ashes; when heated in a close vessel, it becomes black. It is slightly resino-electric by friction. Its constituents are, alumina 16, mellitic acid 46, water of crystallization 38.—*Klaproth*. It occurs superimposed on bituminous wood and earth coal, and is usually accompanied with sulphur. It has hitherto been found only at Artern in Thuringia.

MELTING. See CALORIC, *change of state*, and FUSIBILITY.

MEMBRANES of animals consist of concrete gelatin, and are, like skins, convertible into leather by tannin.

MENACHANITE. Colour grayish-black. Occurs only in very small flattish angular grains, which have a rough glimmering surface. Glistening; adamantine, or semi-metallic lustre. Cleavage imperfect. Opaque. Not so hard as magnetic iron-sand. Brittle. Retains its colour in the streak. Sp. gr. 4.3 to 4·4. It is attractible by the magnet, but in a much weaker degree than magnetic iron-stone. Infusible without addition. It tinges borax of a greenish colour. Its constituents are, oxide of iron 51, oxide of titanium 45·25, oxide of manganese 0·25, silica 3·5.—*Klaproth*. It is found, accompanied with fine quartz-sand, in the bed of a rivulet which enters the valley of Manaccan in Cornwall.

MENILITE. A sub-species of indivisible quartz. It is of two kinds—the brown and the gray. *Brown menilite* is chestnut-brown, inclining to liver-brown. It occurs tuberose. External surface, rough and dull; internal, glistening. It has sometimes a tendency to lamellar distinct concretions. Fracture very flat conchoidal. Translucent on the edges. Scratches glass. Easily frangible. Sp. gr. 2·17. Infusible. Its constituents are, silica 85·5, alumina 1, lime 0·5, oxide of iron 0·5, water and carbonaceous matter 11·0. Found at Menil Montant near Paris, imbedded in adhesive slate, as flint is in chalk.

Gray Menilite. Colour yellowish-gray. Tuberose. Internally glimmering or dull. Fracture as above. Semi-hard in a high degree. Easily frangible. Sp. gr. 2·3. It occurs at Argenteuil near Paris, imbedded in a clayey marle.—*Jameson*.

MEPHITIC ACID. CARBONIC ACID.

MENSTRUUM. A word synonymous with solvent.

MERCURY is distinguished from all other metals by its extreme fusibility, which is such, that it does not take the solid state until cooled to the thirty-ninth degree below 0 on Fahrenheit's thermometer; and of course it is always fluid in the temperate climates of the earth. Its colour is white, and rather bluer than silver. In the solid state it is malleable[*]; its specific gravity is 13·6. It is volatile, and rises in small portions at the common temperature of the atmosphere, as is evinced by several experiments, more especially in a vacuum, such as obtains in the upper part of a barometer tube. At the temperature of about 656° it boils rapidly, and rises copiously in fumes. When exposed to such a heat as may cause it to rise quickly in the vaporous form, or about 600°, it gradually becomes converted into a red oxide, provided oxygen be present. This was formerly known by the name of precipitate *per se*. A greater heat, however, revives this metallic oxide, at the same time that the oxygen is again extricated. Ten days or a fortnight's constant heat is required to convert a few grains of mercury into precipitate *per se* in the small way.

From this volatility of mercury, it is commonly purified by distillation.

Mercury is not perceptibly altered by mere exposure to the air; though by long agitation, with access of air, it becomes converted into a black powder or oxide, which gives out oxygen by heat, the metal being at the same time revived.

When calomel or protochloride of mercury is acted on by potash-water, it yields the pure black protoxide; and when corrosive sublimate or the deutochloride is treated in the same way, it affords the red deutoxide. The former oxide, heated with access of air, slowly changes into the latter. The constituents of the first are 100 metal + 4 oxygen; of the second 100 + 8. Hence the prime equivalent of mercury is 25. At a red heat both oxides emit their oxygen, and pass to the metallic state. A moderate heat converts the black oxide partly into running mercury and partly into red oxide. The deutoxide, as usually prepared from the nitrate by gentle calcination, is in brilliant red scales, which become of an orange hue when finely comminuted. It frequently contains a little undecomposed subnitrate.

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[*] The reader will find an ample account of the freezing of quicksilver in Dr. Blagden's History, vol. lxxxiii. of the Philosophical Transactions.

By triturating mercury with unctuous or viscid matters, it is changed partly into protoxide, and partly into very minute globules. By exposing mercurial ointment to a moderate heat, the globules fall down, while a proportion of the oxide remains combined with the grease. This light gray chemical compound is supposed to possess all the virtues of the dark coloured ointment, and to be cheaper and more convenient in the application. Mr. Donovan, who introduced it, forms it directly by exposing a mixture of 1 part of black oxide and 24 parts of hog's-lard to a heat of 350°, for about two hours.

Red oxide of mercury is acrid and poisonous, and carries these qualities into its saline combinations. The protoxide is relatively bland, and is the basis of all the mild mercurial medicines.

1. When mercury is heated in chlorine, it burns with a pale red flame, and the substance called corrosive sublimate is formed. This *deutochloride* may also be formed by mixing together equal parts of dry bideutosulphate of mercury and common salt, and subliming. The corrosive sublimate rises, and incrusts the top of the vessel, in the form of a beautiful white semitransparent mass, composed of very small prismatic needles. It may be obtained in cubes, and rhomboidal prisms, or quadrangular prisms, with their sides alternately narrower, and terminated by dihedral summits. Its sp. gr. is 5·14. Its taste is acrid, stypto-metallic, and eminently disagreeable. It is a deadly poison. Twenty parts of cold water dissolve it, and less than one of boiling water. 100 parts of alcohol at the boiling temperature dissolve 88 of corrosive sublimate; and at 70° they dissolve 37.5 parts. The constituents of this chloride are,—

Mercury,	25	. . 73·53
Chlorine,	9	. . 26·47

It may be recognized by the following characters: It volatilizes in white fumes, which seem to tarnish a bright copperplate, but really communicate a coating of metallic mercury, which appears glossy white on friction. When caustic potash is made to act on it, with heat, in a glass tube, a red colour appears, which by gentle ignition vanishes, and metallic mercury is then found to line the upper part of the tube in minute globules. Solution of corrosive sublimate reddens litmus paper; but changes syrup of violets to green. Bicarbonate of potash throws down from it a deep brick-red precipitate, from which metallic mercury may be procured by heating it in a tube. Caustic potash gives a yellow precipitate; but if the solution be very dilute, a white cloud only is occasioned, which becomes yellowish-red on subsidence. Lime water causes a deep yellow, verging on red. Water of ammonia forms a white precipitate, which becomes yellow on being heated. With sulphuretted hydrogen and hydrosulphurets, a black or blackish-brown precipitate appears. Nitrate of silver throws down the curdy precipitate characteristic of muriatic acid; and the protomuriate of tin gives a white precipitate. The proper antidote to the poison of corrosive sublimate, is the white of egg or albumen, which converts it into calomel. Sulphuretted hydrogen water may also be employed, along with emetics. From six to twelve grains were the mortal doses employed by Orfila in his experiments on dogs. They died in horrible convulsions, generally in two hours. But when, with the larger quantity, the whites of eight eggs were thrown into the stomach, the animals soon recovered, after vomiting. Corrosive sublimate, digested with albumen for some time, was given in considerable doses with impunity. The instructions given under *Arsenic*, for examination of the bowels of a person supposed to be poisoned are equally applicable to poisoning by corrosive sublimate; and the appearances are much the same.

2. *Protochloride* of mercury, *mercurius dulcis*, or *calomel*, is usually formed from the deutochloride, by triturating four parts of the latter with three of quicksilver, till the globules disappear, and subjecting the mixture to a subliming heat. By levigating and edulcorating with warm water the sublimed grayish-white cake, the portion of soluble corrosive sublimate which had escaped decomposition is removed. It may also be made by adding solution of protonitrate of mercury to solution of common salt. The protochloride or calomel precipitates. The following is the process used at Apothecaries' Hall, London: 50lbs. of mercury are boiled with 70lbs. of sulphuric acid, to dryness, in a cast-iron vessel; 62lbs. of the dry salt are triturated with 40½lbs. of mercury, until the globules disappear, and 34lbs. of common salt are then added. This mixture is submitted to heat in earthen vessels, and from 95 to 100lbs. of calomel are the result. It is washed in large quantities of distilled water, after having been ground to a fine and impalpable powder.

When protochloride of mercury is very slowly sublimed, four-sided prisms, terminated by pyramids, are obtained. It is nearly tasteless and insoluble, and is purgative in doses of five or six grains. Its sp. gr. is 7.176. Exposure to air darkens its surface. When two pieces are rubbed in the dark, they phosphoresce. It is not so volatile as the deutochloride. Nitric acid dissolves calomel, converting it into corrosive sublimate. Protochloride of mercury is composed of

Mercury,	25.	84.746
Chlorine,	4.5	15.254

We have also two sulphurets of mercury; the black or *ethiops mineral*, and the red or *cinnabar*.

The first is easily made by heating or triturating the ingredients together, or by adding a hydrosulphuret of alkali to a mercurial saline solution. It consists of

Mercury,	25	92·6
Sulphur,	2	7·4

When the black sulphuret is exposed to a red heat in earthen pots, cinnabar sublimes, which, when reduced to powder, is of a beautiful red colour, and is used as a pigment, under the name of *vermilion*. Its sp. gr. is about 10. It is insoluble in water, insipid, and burns with a blue flame If it be mixed with half its weight of iron filings, and distilled in a retort, it yields pure mercury. It is deutosulphuret, and consists of

Mercury,	25	86·2
Sulphur,	4	13·8

The salts of mercury have the following general characters:

1. A dull red heat volatilizes them.
2. Ferroprussiate of potash gives a white precipitate.
3. Hydrosulphuret, black.
4. Muriate of soda, with the protosalts, white.
5. Gallic acid, orange yellow.
6. Plate of copper, quicksilver.

The sulphuric acid does not act on this metal, unless it be well concentrated and boiling. For this purpose mercury is poured into a glass retort, with nearly twice its weight of sulphuric acid. As soon as the mixture is heated, a strong effervescence takes place, sulphurous acid gas escapes, the surface of the mercury becomes white, and a white powder is produced: when the gas ceases to come over, the mercury is found to be converted into a white, opaque, caustic, saline mass, at the bottom of the retort, which weighs one-third more than the mercury, and is decomposed by heat. Its fixity is considerably greater than that of mercury itself. If the heat be raised, it gives out a considerable quantity of oxygen, the mercury being at the same time revived.

Water resolves it into two salts, the bisulphate and subsulphate; the latter is of a yellow colour. Much washing is required to produce this colour, if cold water be used; but if a large quantity of hot water be poured on, it immediately assumes a bright lemon colour. In this state it is called *turbith mineral*. The other affords by evaporation, small, needly, deliquescent crystals.

The fixed alkalis, magnesia, and lime, precipitate oxide of mercury from its solutions; these precipitates are reducible in closed vessels by mere heat without addition.

The nitric acid rapidly attacks and dissolves mercury, at the same time that a large quantity of nitrous gas is disengaged; and the colour of the acid becomes green during its escape. Strong nitric acid takes up its own weight of mercury in the cold; and this solution will bear to be diluted with water. But if the solution be made with the assistance of heat, a much larger quantity is dissolved; and a precipitate will be afforded by the addition of distilled water, which is of a yellow colour if the water be hot, or white if it be cold; and greatly resembles the turbith mineral produced with sulphuric acid: it has accordingly been called *nitrous turbith*.

All the combinations of mercury and nitric acid are very caustic, and form a deep purple or black spot upon the skin. They afford crystals, which differ according to the state of the solution. When nitric acid has taken up as much mercury as it can dissolve by heat, it usually assumes the form of a white saline mass. When the combination of nitric acid and mercury is exposed to a gradual and long continued low heat, it gives out a portion of nitric acid, and becomes converted into a bright red oxide, still retaining a small portion of acid. This is known by the name of *red precipitate*, and is much used as an escharotic.

When red precipitate is strongly heated, a large quantity of oxygen is disengaged, together with some nitrogen, and the mercury is sublimed in the metallic form.

Nitrate of mercury is more soluble in hot than cold water, and affords crystals by cooling. It is decomposed by the affusion of a large quantity of water, unless the acid be in excess.

A fulminating preparation of mercury was discovered by Mr. Howard. A hundred grains of mercury are to be dissolved by heat in an ounce and a half by measure of nitric acid. This solution being poured cold into two ounces by measure of alcohol in a glass vessel, heat is to be applied till effervescence is excited. A white vapour undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filter, well washed, and cautiously dried with a very moderate heat. This powder detonates loudly by gentle heat, or slight friction.

The acetic and most other acids combine with the oxide of mercury, and precipitate it from its solution in the nitric acid. See Salt.

When one part of native sulphuret of antimony is triturated or accurately mixed with two parts of corrosive sublimate, and exposed to distillation, the chlorine combines with the antimony, and rises in the form of the compound called butter of antimony; while the sulphur combines with the mercury, and forms cinnabar. If antimony be used instead of the sulphuret, the residue which rises last consists of running mercury, instead of cinnabar.

Mercury, being habitually fluid, very readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called *amalgams*.

It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic, and antimony; and scarcely at all with platina or iron: it does not unite with nickel, manganese, or cobalt; and its action on tungsten and molybdena is not known. Looking-glasses are covered on the back surface with an amalgam of tin. See Silvering.

Some of the uses of mercury have already been mentioned in the present article. The amalgamation of the noble metals, water-gilding, the making of vermilion, the silvering of looking-glasses, the making of barometers and thermometers, and the preparation of several powerful medicines, are the principal uses to which this metal is applied.

Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing, and becoming covered with a coat of oxide, on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal. Pour off the water, and digest the mercury with a little acetic acid. This will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water. Or to this acetic solution add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, 70 per cent. of metal. If only a very minute quantity of lead be present in a large quantity of mercury, it may be detected by solution in nitric acid, and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside if allowed to stand a few days. One part of lead may thus be separated from 15263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested, in like manner, by a weak solution of nitro-muriate of gold, which throws down a purple sediment; and zinc by exposing the metal to heat.

The *black oxide* is rarely adulterated, as it would be difficult to find a substance well suited to this purpose. If well prepared, it may be totally volatilized by heat.

The *red oxide* of mercury by *nitric acid* is very liable to adulteration with red lead. It should be totally volatilized by heat.

Red sulphuret of mercury is frequently adulterated with red lead; which may be detected by heat.

Corrosive muriate of mercury. If there be any reason to suspect arsenic in this salt, the fraud may be discovered as follows: Dissolve a small quantity of the sublimate in distilled water; add a solution of carbonate of ammonia till the precipitation ceases, and filter the solution. If, on the addition of a few drops of ammoniated copper to this solution, a precipitate of a yellowish-green colour be produced, the sublimate contains arsenic.

Sub-muriate of mercury, or calomel, should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with a thirty-second part of muriate of ammonia in ten parts of distilled water. When carbonate of potash is added to the filtered solution, no precipitation will ensue, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should become intensely black, and should exhibit nothing of an orange hue.

MESOLYTE. Needle-stone.

MESOTYPE. Prismatic zeolite. This species of the genus zeolite is divided by Professor Jameson into three sub-species,—the fibrous zeolite, natrolite, and mealy zeolite; which see.

METALS. The most numerous class of undecompounded chemical bodies, distinguished by the following general characters:—

1. They possess a peculiar lustre, which continues in the streak, and in their smallest fragments.

2. They are fusible by heat; and in fusion retain their lustre and opacity.

3. They are all, except selenium, excellent conductors both of electricity and caloric.

4. Many of them may be extended under the hammer, and are called malleable; or under the rolling press, and are called laminable; or drawn into wire, and are called ductile. This capability of extension depends, in some measure, on a tenacity peculiar to the metals, and which exists in the different species with very different degrees of force. See Cohesion.

5. When their saline combinations are electrized, the metals separate at the resino-electric or negative pole.

6. When exposed to the action of oxygen, chlorine, or iodine, at an elevated temperature, they generally take fire, and, combining with one or other of these three elementary dissolvents in definite proportions, are converted into earthy or saline looking bodies, devoid of metallic lustre and ductility, called oxides, chlorides, or iodides.

7. They are capable of combining in their

8. From this brilliancy and opacity conjointly, they reflect the greater part of the light which falls on their surface, and hence form excellent mirrors.

9. Most of them combine in definite proportions with sulphur and phosphorus, forming bodies frequently of a semi-metallic aspect; and others unite with hydrogen, carbon, and boron, giving rise to peculiar gaseous or solid compounds.

10. Many of the metals are capable of assuming, by particular management, crystalline forms; which are, for the most part, either cubes or octohedrons.

The relations of the metals to the various objects of chemistry, are so complex and diversified, as to render their classification a task of peculiar difficulty. I have not seen any arrangement to which important objections may not be offered; nor do I hope to present one which shall be exempt from criticism. The main purposes of a methodical distribution are to facilitate the acquirement, retention, and application of knowledge. With regard to metals in general, I conceive these purposes may be to a considerable extent attained, by beginning with those which are most eminently endowed with the characters of the genus, which most distinctly possess the properties that constitute their value in common life, and which caused the early inhabitants of the earth to give to the first metallurgists a place

Quique sui memores, alios fecêre merendo.

By arranging metals according to the degree in which they possess the obvious qualities of unalterability, by common agents, tenacity, and lustre, we also conciliate their most important chemical relations, namely, those to oxygen, chlorine, and iodine; since their metallic pre-eminence is, popularly speaking, inversely as their affinities for these dissolvents. In a strictly scientific view, their habitudes with oxygen should perhaps be less regarded in their classification, than with chlorine, for this element has the most energetic attraction for the metals. But, on the other hand, oxygen, which forms one-fifth of the atmospheric volume, and eight-ninths of the aqueous mass, operates to a much greater extent among metallic bodies, and incessantly modifies their form, both in nature and art. Now the order we propose to follow will indicate very nearly their relations to oxygen. As we progressively descend, the influence of that beautiful element progressively increases. Among the bodies near the head, its powers are subjugated by the metallic constitution; but among those near the bottom, it exercises an almost despotic sway, which Volta's magical pile, directed by the genius of Davy, can only suspend for a season. The emancipated metal soon relapses under the dominion of oxygen.

General Table of the Metals.

NAMES.	Sp. gr.	Precipitants.	Colour of Precipitates by			
			Ferroprussiate of potash.	Infusion of galls.	Hydrosulphurets.	Sulphuretted hydrogen.
1 Platinum	21.47	Mur. ammon.	0	0		Black met. powd.
2 Gold	19.30	Sulph. iron Nitr. mercury	Yellowish-white	Green; met.	Yellow	Yellow
3 Silver	10.45	Common salt	White	Yel.-Brown	Black	Black
4 Palladium	11.8	Prus. mercury	Deep orange		Blackish-brown	Black-brown
5 Mercury	13.6	Common salt Heat	White passing to yellow	Orange-yellow	Brownish-black	Black
6 Copper	8.9	Iron	Red-brown	Brown	Black	Do.
7 Iron	7.7	Succinc soda with perox.	Blue, or white passing to blue	Protox. 0 Perox. black	Black	0
8 Tin	7.29	Cor. sublim.	White	0	Protox black Perox. yellow	Brown
9 Lead	11.35	Sulph. soda	Do.	White	Black	Black
10 Nickel	8.4	Sulph. potash?	Do.	Grey-white	Do.	0
11 Cadmium	8.6	Zinc	Do.	0	Orange-yellow	Orange-yellow
12 Zinc	6.9	Alk. carbonates	Do.	0	White	Yellowish-white
13 Bismuth	9.88	Water	Do.	Yellow	Black-brown	Black-brown
14 Antimony	6.70	Water Zinc	With dilute solutions white	White from water	Orange	Orange
15 Manganese	8.	Tartr. pot.	White	0	White	Milkiness
16 Cobalt	8.6	Alk. carbonates	Brown-yellow	Yellow-white	Black	0
17 Tellurium	6.115	Water Antimony	0	Yellow	Blackish	
18 Arsenic	8.35? 5.70?	Nitr. lead	White		Yellow	Yellow
19 Chromium	5.90	Do.	Green	Brown	Green	
20 Molybdenum	8.6	Do.?	Brown	Deep brown		Brown

21 Tungsten	17.4	Dilute acids				
22 Columbium	6.6 ?	Zinc or inf. galls	Olive	Orange	Chocolate	
23 Selenium	4.3 ?	Iron Sulphite amm.				
24 Osmium	?	Mercury		Purple passing to deep blue		
25 Rhodium	10.65	Zinc ?	0		0	
26 Iridium	18.68	Do. ?	0	0		
27 Uranium	9.0	Ferrop. pot.	Brown-red	Chocolate	Brown-yellow	0
28 Titanium	?	Inf. galls.	Grass-green	Red-brown	Grass-green	0
29 Cerium	?	Oxal. amm.	Milk-white	0	White	0
30 Potassium	0.865	Mur. plat. Tart. acid	0	0	0	0
31 Sodium	0.972					
32 Lithium						
33 Calcium						
34 Barium						
35 Strontium						
36 Magnesium						
37 Yttrium						
38 Glucinum						
39 Aluminum						
40 Zirconium						
41 Silicium						

The first 12 are malleable; and so are the 30th, 31st, and 32d in their congealed state.

The first 16 yield oxides, which are neutral salifiable bases.

The metals 17, 18, 19, 20, 21, 22, and 23, are acidifiable by combination with oxygen. Of the oxides of the rest, up to the 30th, little is known. The remaining metals form, with oxygen, the alkaline and earthy bases.

The order of their affinity for oxygen, as far as it has been ascertained, is stated in the table of Elective ATTRACTION of oxygen and the metals.

We shall now give an example of the method of analyzing a metallic alloy, of silver, copper, lead, bismuth, and tin.

Let it be dissolved, with the aid of heat, in an excess of nitric acid, sp. gr. 1.23. Evaporate the solution almost to dryness, and pour water on the residuum. We shall thus obtain a solution of the nitrates of silver, copper, and lead, while the oxides of tin and bismuth will be left at the bottom. By exposing the latter mixture to the action of nitric acid, the oxide of bismuth will be separated from that of tin. To determine the proportions of the other metals, we pour first into the hot and pretty dilute solution, muriatic acid, which will throw down the silver. After filtration, we add sulphate of soda, to separate the lead; and finally, carbonate of potash to precipitate the zinc. The quantity of each metal may now be deduced from the weight of each precipitate, according to its specific nature, agreeably to the principles of composition given under the individual metals. See ORES (*Analysis of*).

METEORITES, OR METEORIC STONES, are peculiar solid compounds of earthy and metallic matters, of singular aspect and composition, which occasionally descend from the atmosphere, usually from the bosom of a luminous meteor. This phenomenon affords an instructive example of the triumph of human testimony over philosophical scepticism. The chronicles of almost every age had recorded the fall of ponderous stony or earthy masses from the air, but the evidence had been rejected by historians, because the phenomenon was not within the range of *their philosophy*. At length the sober and solid researches of physical science put to shame the incredulity of the metaphysical school.

M. Abel Remusat shows in his translation recently made of the work of *Ma-Touan-Lin*, a Chinese author of the 13th century, that the Chinese and Japanese noted with much precision every thing connected with the appearance of these singular phenomena. They remarked that the stones fell sometimes in perfectly serene weather; they compared the explosions which took place to thunder, to the noise of a tumbling wall, to the bellowing of an ox. The hissing which accompanies their fall was likened to the sounding of the wings of birds of prey, or of cloth torn asunder. According to them, the stones are always burning hot at the moment when they reach the ground; their outward surface is black; some of them ring when struck, like metallic bodies. The name which they give them means, *falling stars changed into stones.*

The Chinese believed that the appearances of aërolites were connected with contemporary events; for which reason they formed catalogues of them! We have little reason to laugh at this Oriental prejudice. Were the *philosophers* of Europe wiser, when resisting the evidence of facts, they affirmed that the falls of stones from the atmosphere were *impossible?* The Academy of Sciences declared in 1769, that a stone picked up at the instant of its fall, near Lucé, by several persons, *who had followed its descent with their eyes to the spot where it struck the ground, did not fall from the sky*. Finally, the *procès-verbal* of the municipality of *Lagrange de Juliac*, affirming that on the 30th Aug. 1790, there fell in the fields, on the roofs of houses, in the streets of the village, a great quantity of stones, was treated in the journals of the time as a *ridiculous tale*, *made to excite the* PITY *not only of men of learning, but of all rational beings*. "Philosophers," says Chladni, "who will *not* admit facts which they cannot explain, injure the advancement of science, as much as those to whom too great credulity may be reproached."

"While all Europe," says the celebrated Vauquelin, "resounded with the rumour of stones fallen from the heavens; and while philosophers, distracted in opinion, were framing hypotheses to explain their origin, each according to his own fancy, the Hon. Mr. Howard, an able English chemist, was pursuing in silence the only route which could lead to a solution of the problem. He collected specimens of stones which had fallen at different times, procured as much information as possible respecting them, compared the physical or exterior characters of these bodies; and even did more, in subjecting them to chemical analysis, by means as ingenious as exact.

"It results from his researches, that the stones which fell in England, in Italy, in Germany, in the East Indies, and in other places, have all such a perfect resemblance, that it is almost impossible to distinguish them from each other; and what renders the similitude more perfect and more striking is, that they are composed of the same principles, and nearly in the same proportions."

I have given this just and handsome tribute to English genius in the form of a quotation from the French chemist; by appropriating the language to one's self, as has been practised in a recent compilation, the force of the compliment is in a great measure done away.

"I should have abstained," continues M. Vauquelin, "from any public notice of an object, which has been treated of in so able a manner by the English chemist, if he himself had not induced me to do so, during his residence in Paris; had not the stones which I analysed been from another country; and had not the interest excited by the subject rendered this repetition excusable.

"It is therefore to gratify Mr. Howard; to give, if possible, more weight to his experiments; and to enable philosophers to place full confidence in them, rather than to offer any thing new, that I publish this memoir." *Journal des Mines*, No. 76; and *Tilloch's Mag*. vol. xv. p. 346.

It is remarkable, that all the stones, at whatever period, or in whatever part of the world they may have fallen, have appeared, as far as they have been examined, to consist of the same substances; and to have nothing similar to them, not only among the minerals in the neighbourhood of the places where they were found, but among all that have hitherto been discovered in our earth, as far as men have been able to penetrate. For the chemical analysis of a considerable number of specimens we are particularly indebted to Mr. Howard, as well as to Klaproth and Vauquelin, and a precise mineralogical description of them has been given by the Count de Bournon and others.

They are all covered with a thin crust of a deep black colour, they are without gloss, and their surface is roughened with small asperities. Internally they are grayish, and of a granulated texture, more or less fine. Four different substances are interspersed among their texture, easily distinguished by a lens. The most abundant is from the size of a pin's head to that of a pea, opaque, with a little lustre like that of enamel, of a gray colour sometimes inclined to brown, and hard enough to give faint sparks with steel. Another is a martial pyrites, of a reddish-yellow colour, black when powdered, not very firm in its texture, and not attractible by the magnet. A third consists of small particles of iron in a perfectly metallic state, which give to the mass the quality of being attracted by the magnet, though in some specimens they do not exceed two per cent. of the whole weight, while in others they extend to a fourth. These are connected together by a fourth of an earthy consistence in most, so that they may be broken to pieces by the fingers with more or less difficulty. The black crust is hard enough to emit sparks with steel, but may be broken by a stroke with a hammer, and appears to possess the properties of the very attractible black oxide of iron. Their specific gravity varies from 3·352 to 4·281.

The crust appears to contain nickel united with iron, but Mr. Hatchett could not determine its proportion. The pyrites he estimates at iron ·68, sulphur ·13, nickel ·06, extraneous earthy matter ·13. In the metallic particles disseminated through the mass, the nickel was in the proportion of one part, or thereabout, to three of iron. The hard separate bodies gave silex ·50, magnesia ·15, oxide of iron ·34, oxide of nickel ·025; and the cement, or matrix, silex ·48, magnesia ·18, oxide of iron ·34, oxide of nickel ·025. The increase of weight in both these arose from the higher oxidation of the iron. These proportions are taken from the stones that fell at Benares on the 19th of December, 1798.

M. G. Rose of Berlin has succeeded in separating crystals of pyroxene from a large specimen of the aërolite of Juvenas, and has measured the angles with the reflective goniometer; one of the crystals is of the octohedral variety, represented in the 109th figure of Haüy's Mineralogy. The same rocky tissue contains microscope hemitrope crystals, which appear to be felspar, with a base of soda, i. e. albite. In the aërolite of Pallas the olivine is perfectly crystallized.

The solitary masses of native iron that have been found in Siberia, Bohemia, Senegal, and South America, likewise agree in the circumstance of being an alloy of iron and nickel; and are either of a cellular texture, or have earthy matter disseminated among the metal. Hence, a similar origin has been ascribed to them.

Laugier, and afterward Thenard, found chrome likewise, in the proportion of about one per cent., in different meteoric stones they examined.

In all the instances in which these stones have been supposed to fall from the clouds, and of which any perfect account has been given, the appearance of a luminous meteor, exploding with loud noise, has immediately preceded, and hence has been looked to as the cause. The stones likewise have been more or less hot, when found immediately after their supposed fall. Different opinions, however, have been entertained on this subject, which is certainly involved in much difficulty. Some have supposed them to be merely projected from volcanoes; while others have suggested, that they might be thrown from the moon; or be bodies wandering through space, and at length brought within the sphere of attraction of our planet.

Various lists of the periods, places, and appearances of these showers of stony and earthy matters, have been given from time to time in the scientific journals. The latest and most complete is that published in the 1st vol. of the Ed. Phil. Journ. compiled partly from a printed list by Chladni, and partly from a manuscript one of Mr. Allan, read some years ago at the Royal Society of Edinburgh. It appears that Domenico Troili, a Jesuit, published at Modena, in 1766, a work entitled, *Della Caduta di un Sasso dall Aria, ragionamento*, in which the ingenious author proves, in the clearest manner, both from ancient and modern history, that stones had repeatedly fallen from the heavens. This curious dissertation (*ragionamento*) is in the possession of Mr. Allan. The compiler of the new list justly observes, that nothing can show more strikingly the universality and obstinacy of that scepticism which discredits every thing that it cannot understand, than the circumstance that his work should have produced so little effect, and that the numerous falls of meteoric stones should have so long been ranked among the inventions of ignorant credulity.

Mr. Howard's admirable dissertation was published in the Phil. Trans. for 1802. It is reprinted in the 13th vol. of Tilloch's Magazine, and ought to be studied as a pattern of scientific research. The following Table is copied from the 31st vol. of the *Ann. de Chimie*:—

Chronological List of Meteoric Stones.

Sect. I.—*Before the Christian Era.*

Division I.—Containing those which can be referred pretty nearly to a date.

A. C.

1478. The thunderstone in Crete, mentioned by Malchus, and regarded probably as the symbol of Cybele.—*Chronicle of Paros*, l. 18, 19.

1451. Shower of stones which destroyed the enemies of Joshua at Beth-horon, was probably hail.—*Joshua*, chap. x. 11.

1200. Stones preserved at Orchomenos.—*Pausanias.*

1168. A mass of iron upon Mount Ida in Crete.—*Chronicle of Paros*, l. 22.

705 or 704. The *Ancyle* or sacred shield, which fell in the reign of Numa. It had nearly the same shape as those which fell at the Cape and at Agram.—*Plutarch, in Num.*

654. Stones which fell upon Mount Alba in the reign of Tullus Hostilius.—"*Crebri cecidere cælo lapides.*"—*Liv.* l. 30.

644. Five stones which fell in China, in the country of Song.—*De Guignes.*

465. A large stone at Ægospotamos, which Anaxagoras supposed to come from the sun. It was as large as a cart, and of a burnt colour.—"*Qui lapis etiam nunc ostenditur, magnitudine vehis, colore adusto.*"—*Plutarch, Pliny*, lib. ii. cap. 58.

465. A stone near Thebes.—*Scholiast of Pindar.*

211. Stones fell in China along with a falling star.—*De Guignes*, &c.

205 or 206. Fiery stones.—*Plutarch. Fab. Max.* cap. 2.

192. Stone fell in China.—*De Guignes.*

176. A stone fell in the Lake of Mars.—"*Lapidem in Agro Crustumino in Lacum Martis de cælo cecidisse.*"—*Liv.* xli. 3.

90 or 89. "*Eodem causam dicente, lateribus coctis pluisse, in ejus anni acta relatum est.*"—*Plin. Nat. Hist.* lib. ii. cap. 56.

89. Two large stones fell at Yong in China. The sound was heard over 40 leagues.—*De Guignes.*

56 or 52. Spongy iron fell in Lucania.—*Plin.*

46. Stones fell at Acilla.—*Cæsar.*

38. Six stones fell in Leang in China.—*De Guignes.*

29. Four stones fell at Po in China.—*De Guignes.*

22. Eight stones fell from heaven, in China.—*De Guignes.*

12. A stone fell at Ton-Kouan.—*De Guignes.*

9. Two stones fell in China.—*De Guignes.*

6. Sixteen stones fell in Ning-Tcheou, and other two in the same year.—*De Guignes.*

Division II.—Containing those of which the date cannot be determined.

The mother of the Gods, which fell at Pessinus.

The stone preserved at Abydos.—*Plin.*

The stone preserved at Cassandria.—*Plin.*

The Black stone, and also another preserved in the Caaba of Mecca.

The "Thunderbolt, black in appearance like a hard rock, brilliant and sparkling," of which the blacksmith forged the sword of Antar.—See *Quarterly Review*, vol. xxi. p. 225. and *Antar*, translated by T. Hamilton, Esq. p. 152.

The stone preserved in the Coronation Chair of the Kings of England was not meteoric.

Sect. 2.—After the Christian Era.

P. C.

In the years, 2, 106, 154, 310, and 333, stones fell in China. *Abel Remusat. Journ. de Physique*, May, 1819.

A stone in the country of the Vocontini.—*Plin.*

452. Three large stones fell in Thrace.—*Cedrenus and Marcellini, Chronicon.* p. 29. —"*Hoc tempore,*" says Marcellinus, "*tres magni lapides e cælo in Thracia ceciderunt.*"

Sixth Century. Stones fell upon Mount Lebanon, and near Emisa in Syria.—*Damascius.*

About 570. Stones near Bender in Arabia. —*Alkoran*, viii. 16. and cv. 3. and 4.

648. A fiery stone at Constantinople.—*Several Chronicles.*

823. A shower of pebbles in Saxony.

839. Stones fell in Japan. *Abel Remusat.*

852. A stone fell in Tabaristan, in July or August.—*De Sacy* and *Quatremere.*

856. In December, five stones fell in Egypt. *The same.*

885. Stones fell in Japan. *Abel Remusat.*

897. A stone fell at Ahmedabad.—*Quatremere.* In 892, according to the *Chron. Syr.*

921. Great stones fell at Narni. *Benedictus de Saint-Andrea*, in the library of prince Chigi at Rome.

951. A stone fell near Augsburg.—*Alb. Stad*, and others.

998. Two stones fell, one near the Elbe, and the other in the town of Magdeburg. —*Cosmas* and *Spangenberg.*

1009. A mass of iron fell in Djordjan.—*Avicenna.*

1021. Stones fell in Africa between the 24th July and the 21st of August.—*De Sacy.*

1112. Stones or iron fell near Aquileja.—*Valvasor.*

1135 or 1136. A stone fell at Oldisleben in Thuringia.—*Spangenberg*, and others.

1164. During Pentecost, iron fell in Misnia.—*Fabricius.*

1249. Stones fell at Quedlinbourg, Ballenstadt, and Blackenburg, on the 26th July. —*Spangenberg* and *Rivander.*

Thirteenth Century. A stone fell at Wurzburg.—*Schottus, Phys. Cur.*

Between 1251 and 1363. Stones fell at Welikoi-Usting in Russia.—*Gilbert's Annal.* tom. 35.

1280. A stone fell at Alexandria in Egypt. —*De Sacy.*

1300 nearly. Great stones fell in Aragon. *Manuscript chronicle in the national museum of Pest in Hungary.*

1304, Oct. 1. Stones fell at Friedland or Friedberg.—*Kranz* and *Spangenberg.*

1305. Stones fell in the country of the Vandals.

1328, Jan. 9. In Mortahiah and Dakhaliah. —*Quatremere.*

1368. A mass of iron in the Duchy of Oldenburg.—*Siebrand, Meyer.*

1379, May 26. Stones fell at Minden in Hanover.—*Lerbecius.*

1421. A stone fell in the island of Java.—*Sir T. S. Raffles.*

1438. A shower of spongy stones at Roa, near Burgos in Spain.—*Proust.*

—— A stone fell near Lucerne.—*Cysat.*

1474. Two great stones fell near Viterbo.—*Biblioteca Italiana*, Sept. 1820.

1491, March 22. A stone fell near Crema.—*Simoneta.*

1492, Nov. 7. A stone of 260lb. fell at Ensisheim near Sturgau, in Alsace. It is now in the library of Colmar, and has been reduced to 150lb.—Trithemius, *Hirsaug. Annal. Conrad Gesner, Liber de Rerum Fossilium Figuris*, cap. 3, p. 66. in his *Opera, Zurich*, 1565.

1496, Jan. 26. or 28. Three stones fell between Cesena and Bertonori.—*Buriel* and *Sabellicus.*

1511, Sept. 4. Several stones, some of which weighed 11lb. and others 8lb. fell at Crema. —*Giovanni del Prato*, and others.

1520, May. Stones fell in Aragon.—*Diego de Sayas.*

1540, April 28. A stone fell in the Limousin. —*Bonav. de St. Amable.* ?

Between 1540 and 1550. A mass of iron fell in the forest of Naunhoff.—*Chronicle of the Mines of Misnia.*

—— Iron fell in Piedmont.—*Mercati* and *Scaliger.*

1548, Nov. 6. A black mass fell at Mansfeld in Thuringia.—*Bonav. de St. Amable.*

1552, May 19. Stones fell in Thuringia near Schlossingen.—*Spangenberg.*

1559. Two large stones, as large as a man's head, fell at Miscolz in Hungary, which are said to be preserved in the treasury at Vienna.—*Sthuanfi.*

1561, May 17. A stone called the *Arx Julia* fell at Torgau and Eilenburg.—*Gesner* and *De Boot.*

1580, May 27. Stones fell near Gottingen. -- *Bange.*

1581, July 26. A stone, 39lb. weight, fell in Thuringia. It was so hot that no person could touch it.—*Binhard*, *Olearius.*

1583, Jan. 9. Stones fell at Castrovillari. —*Casto*, *Mercati*, and *Imperati.*

—— March 2. A stone fell in Piedmont of the size of a grenade.

1591, June 19. Some large stones fell at Kunnersdorf.—*Lucas.*

1596, March 1. Stones fell at Crevalcore. —*Mittarelli.*

In the *Sixteenth Century*, not in 1603. A stone fell in the kingdom of Valencia.—*Cæsius* and the *Jesuits of Coimbra.*

1618, August. A great fall of stones took place in Styria.—*Hammer.*

—— A metallic mass fell in Bohemia.—*Kronland.*

1621, April 17. A mass of iron fell about 100 miles S. E. of Lahore.—*Jehan Guir's Memoirs.*

1622, Jan. 10. A stone fell in Devonshire. —*Rumph.*

1628, April 9. Stones fell near Hatford in Berkshire; one of them weighed 24lb.—*Gent. Mag.* Dec. 1796.

1634, Oct. 27. Stones fell in Charollois.—*Morinus.*

1635, June 21. A stone fell at Vago in Italy. ?

—— July 7. or Sept. 29. A stone, weighing about 11 oz. fell at Calce.—*Vallisnieri*, Opere, vi. 64. ?

1636, March 6. A burnt-looking stone fell between Sagan and Dubrow in Silesia.—*Lucas* and *Cluverius.*

1637, Nov. 29. Gassendi says, a stone of a black metallic colour fell on Mount Vaision, between Guillaume and Perne in Provence. It weighed 54 lb. and had the size and shape of the human head. Its specific gravity was 3.5.—*Gassendi*, *Opera*, p. 96. Lyons, 1658.

1642, August 4. A stone weighing 4lb. fell between Woodbridge and Aldborough in Suffolk.—*Gent. Mag.* Dec. 1796.

1643, or 1644. Stones fell in the sea.—*Wurfbain.*

1647, Feb. 18. A stone fell near Zwickau. —*Schmid.*

—— August. Stones fell in the bailliage of Stolzenau in Westphalia.—*Gilbert's Annal.*

Between 1647 and 1654. A mass fell in the sea.—*Willman.*

1650, August 6. A stone fell at Dordrecht. —*Senguerd.*

1654, March 30. Stones fell in the island of Funen.—*Bartholinus.*

A large stone fell at Warsaw.—*Petr. Borellus.*

A small stone fell at Milan, and killed a Franciscan.—*Museum Septalianum.*

1668, June 19 or 21. Two stones, one 300lb. and the other 200lb. weight, fell near Verona.—Legallois, *Conversations*, &c. Paris, 1672. Valisnieri, *Opere*, ii. p. 64. 66. *Montanari* and *Francisco Carli*, who published a letter, containing several curious notices respecting the fall of stones from the heavens.

1671, Feb. 27. Stones fell in Suabia.—*Gilbert's Annal.* tom. xxxiii.

1674, Oct. 6. Two large stones fell near Glaris.—*Scheuchzer.*

Between 1675 and 1677, a stone fell into a fishing-boat near Copinshaw.—Wallace's *Account of Orkney*, and *Gent. Mag.* July, 1806.

1677, May 28. Several stones, which probably contained copper, fell at Ermundorf near Roosenhaven.—Misc. *Nat. Cur.* 1677. App.

1680, May 18. Stones fell at London.—*King.*

1697, Jan. 13. Stones fell at Pentolina near Sienna.—*Soldani* after *Gabrieli.*

1698, May 19. A stone fell at Waltring. —*Scheuchzer.*

1706, June 7. A stone of 72lb. fell at Larissa in Macedonia. It smelt of sulphur, and was like the scum of iron.—*Paul Lucas.*

1715, April 11. Stones fell not far from Stargard in Pomerania. *Ann. de Gilbert*, lxxi. p. 215.

1722, June 5. Stones fell near Scheftlar in Freisingen.—*Meichelbeck.*

1723, June 22. About 33 stones, black and metallic, fell near Plescowitz in Bohemia. —*Rost* and *Stepling.*

1727, July 22. Stones fell at Liboschitz in Bohemia.—*Stepling.*

1738, August 18. Stones fell near Carpentras.—*Castillon.*

1740, Oct. 25. Stones fell at Rasgrad.—*Gilbert's Annal.* tom. l.

—— to 1741. A large stone fell in winter in Greenland.—*Egede.*

1749. Stones fell at Liboschitz in Bohemia. —*Stepling.* ?

1750, Oct. 1. A large stone fell at Niort near Coutance.—*Huard* and *Lalande.*

1751, May 26. Two masses of iron of 71lb. and 16lb. fell in the district of Agram, the capital of Croatia. The largest of these is now in Vienna.

1753, July 3. Four stones, one of which weighed 13lb. fell at Strkow, near Tabor. —*Stepling*, "*De Pluvia Lapidea, anni* 1753, *ad Strkow, et ejus causis, meditatio,*" p. 4.—Prag. 1754.

—— Sept. Two stones, one of 20lb. and the other of 11lb. fell near the villages of Laponas and Pin in Berne.—*Lalande* and *Richard.*

1755, July. A stone fell in Calabria, at Terranuova, which weighed 7lb. 7½oz.—*Domin. Tata.*

1766, end of July. A stone fell at Alboreto in Modena.—*Troili.*

1766, August 15. A stone fell at Novellara. —*Troili.* ?

1768, Sept. 13. A stone fell near Luce in Maine. It was analysed by Lavoisier, &c. —*Mem. Acad. Par.*

—— A stone fell at Aire.—*Mem. Acad. Par.*

—— Nov. 20. A stone, weighing 38lb. fell at Mauerkirchen in Bavaria.—*Imhof.*

1773, Nov. 17. A stone, weighing 9lb. 1oz. fell at Sena in Aragon.—*Proust.*

1775, Sept. 19. Stones fell near Rodach in Cobourg.—*Gilbert's Annal.* tom. xxiii.

—— or 1776. Stones fell at Obruteza in Volhynia.—*Gilbert's Annal.* tom. xxxi.

1776 or 1777, Jan. or Feb. Stones fell near Fabriano.—*Soldani* and *Amoretti.*

1779. Two stones, weighing 3½oz. each, fell at Pettiswoode in Ireland.—*Bingley*, in *Gent. Mag.* Sept. 1796.

1780, April 1. Stones fell near Beeston in England.—*Evening Post.*

About 1780. Masses of iron fell in the territory of Kinsdale, between West-River mountain and Connecticut. *Quarterly Review*, No. 59, April, 1824.

1782. A stone fell near Turin.—*Tata* and *Amoretti.*

1785, Feb. 19. Stones fell at Eichstadt.—*Pickel* and *Stuz.*

1787, Oct. 1. Stones fell in the province of Charkow, in Russia.—*Gilbert's Annal.* tom. xxxi.

1790, July 24. A great shower of stones fell at Barbotan near Roquefort, in the vicinity of Bourdeaux. A mass, 15 inches in diameter, penetrated a hut, and killed a herdsman and a bullock. Some of the stones weighed 25lb. and others 30lb.—*Lomet.*

1791, May 17. Stones fell at Cassel-Berardenga, in Tuscany.—*Soldani.*

—— Oct. 20. Stones fell at Menabilly, in Cornwallis.—*King.*

1794, June 16. Twelve stones, one of which weighed 7½oz. fell at Sienna. Howard and Klaproth have analyzed these stones.—*Phil. Trans.* 1794, p. 103.

1795, April 13. Stones fell at Ceylon.—*Beck.*

—— Dec. 13. A large stone, weighing 55lb. fell near Wold Cottage in Yorkshire. No light accompanied the fall.—*Gent. Mag.* 1796.

1796, Jan. 4. Stones fell near Belaja-Zerkwa in Russia.—*Gilbert's Annal.* tom. xxxv.

—— Feb. 19. A stone of 10lb. fell in Portugal.—Southey's *Letters from Spain.*

1798, March 8. or 12. Stones, one of which was the size of a calf's head, fell at Sales. —*Marquis de Drée.*

—— Dec. 19. Stones fell in Bengal.—*Howard, Lord Valentia.*

1801. Stones fell on the island of Tonneliers.—*Bory de St. Vincent.*

1802, Sept. Stones fell in Scotland? *Monthly Magazine*, Oct. 1802.

1803, April 26. A great fall of stones took place at Aigle. They were about three thousand in number, and the largest weighed about 17lb.

—— July 4. Stones fell at East Norton. *Phil. Mag.* and *Bibl. Brit.*

—— Oct. 8. A stone fell near Apt.

—— Dec. 13. A stone fell near Eggenfelde in Bavaria, weighing 3½lb.—*Imhof.*

1804, April 5. A stone fell at Possil, near Glasgow. *Phil. Mag.*

—— —1807. A stone fell at Dordrécht. *Van Beck Calkoen.*

1805, March 25. Stones fell at Doroninsk in Siberia.—*Gilbert's Annal.* tom. xxix. and xxxi.

—— June. Stones, covered with a black crust, fell in Constantinople. *Kengus Ingigian.*

1806, March 15. Two stones fell at St. Etienne and Valence; one of them weighed 8lb.

—— May 17. A stone, weighing 2½lb. fell near Basingstoke in Hampshire.—*Monthly Magazine.*

1807, March 13. (June 17. according to Lucas). A stone of 160lb. fell at Timochin, in the province of Smolensko in Russia.—*Gilbert's Annal.*

—— Dec. 14. A great shower of stone fell near Weston in Connecticut. Masses of 20lb. 25lb. and 35lb. were found.—*Silliman* and *Kingsley.*

1808, April 19. Stones fell at Borgo San-Donino.—*Guidotti* and *Sgagnoni.*

—— May 22. Stones weighing 4lb. or 5lb. fell near Stannern in Moravia.—*Bibl. Brit.*

—— Sept. 3. Stones fell at *Lissa* in Bohemia.—*De Schreibers.*

1809, June 17. A stone of 6oz. fell on board an American vessel, in latitude 30° 58 N., and longitude 70° 25′ W.—*Bibl. Brit.* ?

1810, Jan. 30. Stones, some of which weighed about 2lb. fell in Caswell county, North America.—*Phil. Mag.* vol. xxxvi.

—— July. A great stone fell at Shahabad in India. It burned five villages, and killed several men and women.—*Phil. Mag.* xxxvii. p. 236.

—— Aug. 10. A stone weighing 7¾lb. fell in the county of Tipperary in Ireland. —*Phil. Mag.* vol. xxxviii. Mr. W. Higgins published an analysis of it.

—— Nov. 23. Stones fell at Mortelle, Villerai, and Moulinbrulé, in the department of the Loiret; one of them weighed 40lb. and the other 20lb.—*Nich. Journal*, vol. xxxix. p. 158.

1811, March 12. or 13. A stone of 15lb. fell in the province of Poltawa in Russia.—*Gilbert's Annals*, xxxviii.

—— July 8. Stones, one of which weighed 3¼oz. fell near Berlanguillas in Spain.—*Bibl. Brit.* tom. xlviii. p. 162.

1812. April 10. A shower of stones fell near Thoulouse.

—— April 15. A stone, the size of a child's head, fell at Erxleben. A specimen of it is in the possession of Professor Haussman of Brunswick.—*Gilbert's Annal.* xl. and xli.

—— Aug. 5. Stones fell at Chantonay.—*Brochant.*

1813, March 14. Stones fell at Cutro in Calabria, during a great fall of red dust. —*Bibl. Brit.* Oct. 1813.

—— Sept. 10. Several stones, one of which weighed 17lb. fell near Limerick in Ireland. —*Phil. Mag.*

1814, Feb. 3. A stone fell near Bacharut in Russia.—*Gilbert's Annal.* tom. 1.

—— Sept. 5. Stones, some of which weighed 18lb. fell in the vicinity of Agen.—*Phil. Mag.* vol. xlv.

—— Nov. 5. Stones, of which 19 were found, fell in the Doab in India.—*Phil. Mag.*

1815, Feb. 18. A stone fell at Duralla in India.—*Phil. Mag. Journal of Science.*

—— Oct. 3. A large stone fell at Chassigny near Langres.—*Pistollet. Ann. de Chim.*

1816. A stone fell at Glastonbury in Somersetshire.—*Phil. Mag.*

1817, May 2. and 3. There is reason to think, that masses of stone fell in the Baltic after the great meteor of Gottenburg.—*Chladni.* ?

1818, Feb. 15. A great stone appears to have fallen at Limoge, but it has not been disinterred.—*Gazette de France*, Feb. 25, 1818.

—— March 30. A stone fell near Zuborzyca in Volhynia (analyzed by *M. Laugier*, *Ann. de Museum*, 17th year, 2d number).

—— July 29. O. S. A stone of 7lb. fell at the village of Slobodka in Smolensko. It penetrated nearly 16 inches into the ground. It had a brown crust with metallic spots.

1819, June 13. Stones fell at Jonzac, department of the lower Charente. These stones contain no nickel.

—— Oct. 13. Stones fell near Politz, not far from Gera or Kostritz, in the principality of Reuss.—*Gilbert's Annals*, lxiii.

1820, 21 to 22 March. A stone fell in the night at Vedenburgh in Hungary.—*Hesperus*, xxvii. *cah.* 3.

—— July 12. A stone fell near Likna, in the circle of Dunaborg, province of Witepsk in Russia.—*Th. Grotthus. Ann. de Gilbert*, lxviii.

1821, June 15. Stones fell near Juvenas, containing no nickel.

1822, June 3. A stone fell at Angers. *Ann. de Chim.*

—— Sept. 10. ——— near Carlstadt in Sweden.

——— 13. ——— near la Baffe, canton of Epinal, department of Vosges. —*Ann. de Chim.*

1823, Aug. 7. ——— near Nobleboro in America.—*Silliman's American Journal*, vii.

1824, towards the end of January. Many stones fell near Arenazzo, in the territory of Bologna. One of them weighing 12 lbs. is preserved in the Observatory of Bologna. —*Diario di Roma.*

—— beginning of February. A great stone fell in the province of Irkutsk in Siberia. —*Some journals.*

—— Oct. 14. A stone fell near Zēbrak, circle of Beraum, in Bohemia. The stone is preserved in the national museum of Prague.

LIST OF MASSES OF IRON SUPPOSED TO HAVE FALLEN FROM THE HEAVENS.

Sect. 1.—*Spongy or Cellular Masses containing Nickel.*

1. The mass found by Pallas in Siberia, to which the Tartars ascribe a meteoric origin. —*Voyages de Pallas*, tom. iv. p. 545. *Paris*, 1793.
2. A fragment found between Eibenstock and Johanngeorgenstadt.
3. A fragment probably from Norway, and in the imperial cabinet of Vienna.
4. A small mass weighing some pounds, and now at Gotha.
5. Two masses in Greenland, out of which the knives of the Esquimaux were made.—See Ross's *Account of an Expedition to the Arctic Regions.*

Sect. 2. *Solid Masses where the Iron exists in Rhomboids or Octohedrons, composed of Strata, and containing Nickel.*

1. The only fall of iron of this kind, is that which took place at Agram, in 1751.
2. A mass of the same kind has been found on the right bank of the Senegal. *Compagnon*, *Forster*, *Goldberry.*
3. At the Cape of Good Hope; Stromeyer has lately detected cobalt in this mass.—*Van Marum* and *Dankelman*; *Brande's Journal*, vol. vi. 162.
4. In different parts of Mexico.—*Sonneschmidt*, *Humboldt*, and the *Gazette de Mexico*, tom. i. and v.
5. In the province of Bahia in Brazil. It is seven feet long, four feet wide, and two feet thick, and its weight about 14,000 lb.—*Mornay* and *Wollaston*; *Phil. Trans.* 1816, p. 270, 281.
6. In the jurisdiction of San Jago del Estera. —*Rubin de Cœlis*, in the *Phil. Trans.* 1788, vol. lxxviii p. 37.
7. At Elbogen in Bohemia.—*Gilbert's Annal.* xlii. and xliv.
8. Near Lenarto in Hungary.—*Ditto*, xlix.

The origin of the following masses seems to be uncertain, as they do not contain nickel, and have a different texture from the preceding:

1. A mass found near the Red River, and sent from New Orleans to New York.—*Journ. des Mines*, 1812, *Bruce's Journ.*
2. A mass at Aix-la-Chapelle containing arsenic.—*Gilbert's Annal.* xlviii.
3. A mass found on the hill of Brianza in the Milanese.—*Chladni* in *Gilbert's Annal.* l. p. 275.
4. A mass found at Groskamdorf, and containing, according to Klaproth, a little lead and copper.

Nickel or chromium is found to be the constant associate of the iron in the meteorolites. They are characteristic of meteoric iron, and are never found in mineral native iron.

Nickel has been hitherto regarded as the sole characteristic ingredient of meteoric stones, but from the analyses of some late meteorolites it would appear, that this metal is occasionally absent, while chromium is always found. Hence the latter has come to be viewed as the constant characteristic.

For a list of meteoric falls of dust, and soft substances, dry or moist, see Chladni in *Ann. de Chim. et Phys.* xxxi. 263.

The phenomenon of red snow observed at Baffin's Bay has of late excited some speculation, being supposed to be a meteoric phenomenon. But Mr. Bauer has proved by microscopic examination, that the colouring particles consist of a new species of the *uredo*, which grows upon the snow, to which he has given the appropriate name of *uredo nivalis*. He found the real diameter of an individual full grown globule of this fungus, to be the *one thousand six hundredth part of an inch*. Hence, in order to cover a single square inch, two million five hundred and sixty thousand of them are necessary. *Journal of Science*, vol. vii. p. 222.

METEOROLOGY. See Climate, Dew, Rain.

MIASCITE. A columnar variety of bitterspar, intermixed with asbestos, from Miaska in Siberia.

MIASMATA. Vapours or effluvia, which, by their application to the human system, are capable of exciting various diseases, of which the principal are intermittent, remittent, and yellow fevers, dysentery and typhus. That of the last is generated in the human body itself, and is sometimes called the typhoid fomes. The other miasmata are produced from moist vegetable matter, in some unknown state of decomposition. The contagious *virus* of the plague, small-pox, measles, chincough, cynanche maligna, and scarlet fever, as well as of typhus and the jail fever, operates to a much more limited distance through the intermedium of the atmosphere than the marsh miasmata. Contact of a diseased person is said to be necessary for the communication of plague; and approach within 2 or 3 yards of him for that of typhus. The Walcheren miasmata extended their pestilential influence to vessels riding at anchor, fully a quarter of a mile from the shore.

The chemical nature of all these poisonous effluvia is little understood. They undoubtedly consist, however, of hydrogen united with sulphur, phosphorus, carbon, and azote, in unknown proportions, and unknown states of combination. The proper neutralizers or destroyers of these gasiform poisons are nitric acid vapour, muriatic acid gas, and chlorine. The last two are the most efficacious; but require to be used in situations from which the patients can be removed at the time of the application. Nitric acid vapour may, however, be diffused in the apartments of the sick, without much inconvenience. Bed-clothes, particularly blankets, can retain the contagious fomes, in an active state, for almost any length of time. Hence, they ought to be fumigated with peculiar care. The vapour of burning sulphur or sulphurous acid is used in the East, against the plague. It is much inferior in power to the other antiloimic reagents. See Fumigation and Chloride of (Lime) at the end.

MICA. Professor Jameson subdivides this mineral species into ten sub-species, viz. mica, pinite, lepidolite, chlorite, green earth, talc, nacrite, potstone, steatite, and figure-stone.

Mica. Colours yellowish and greenish-gray. Massive, disseminated, and crystallized. Its primitive figure is a rhomboid. The secondary forms are; an equiangular six-sided prism, or table; a rectangular four-sided prism, or table; and a six-sided pyramid. Lateral planes smooth and splendent; terminal, longitudinally streaked. Lustre pearly, or semi-metallic. Cleavage single. Fragments tabular and splintery. Translucent. Sectile. Streak gray-coloured. Harder than gypsum, but not so hard as calcareous spar. Feels meagre or smooth. Elastic-flexible. Sp. gr. 2.65. Before the blowpipe it melts into a grayish-white enamel. Its constituents are, silica 47, alumina 22, oxide of iron 15.5, oxide of manganese 1.75, potash 14.5.—*Klaproth.* It occurs along with felspar and quartz in granite and gneiss. It sometimes forms short beds, in granite and other primitive rocks. Most of the mica of commerce is brought from Siberia, where it is used for window-glass.

MICROCOSMIC SALTS. A triple salt of soda, ammonia, and phosphoric acid, obtained from urine, and much used in assays by the blowpipe. This compound is best procured, by mixing equal parts of the phosphate of soda and phosphate of ammonia in solution, and then crystallizing. A faint excess of ammonia is useful in the solution. See Salt.

MIEMITE; of which there are two kinds, the granular and prismatic, both sub-species of dolomite.

Granular miemite. Colour pale asparagus-green. Massive, in granular distinct concretions, and crystallized in flat double three-sided pyramids. Lustre splendent, pearly. Cleavage threefold oblique angular. Translucent. Semi-hard. Brittle. Sp. gr. 2.885. It dissolves slowly, and with little effervescence, in cold nitric acid. Its constituents are, carbonate of lime 53, carbonate of magnesia 42.5, carbonate of iron, with a little manganese, 3.0. It is found at Miemo in Tuscany, imbedded in gypsum, at Hall in the Tyrol, and in Greenland.

Prismatic miemite. Colour asparagus-green. It occurs in prismatic distinct concretions, and crystallized in flat rhomboids, which are deeply truncated on all their edges. Internally shining. Fracture passes from concealed foliated to splintery. Strongly translucent. As hard as the former. Sp. gr. 2.885. It dissolves like the other. Its constituents are, lime 33, magnesia 14.5, oxide of iron 2.5, carbonic acid 47.25, water and loss 2.75. *Klapr.* It occurs in cobalt veins that traverse sandstone, at Glücksbrunn in Gotha.

MILK is a well known fluid, secreted in peculiar vessels of the females of the human species, of quadrupeds, and of cetaceous animals, and destined for the purpose of nourishing their young.

When milk is left to spontaneous decomposition, at a due temperature, it is found to be capable of passing through the vinous, acetous, and putrefactive fermentations. It appears, however, probably on account of the small quantity of alcohol it affords, that the vinous fermentation lasts a very short time, and can scarcely be made to take place in every part of the fluid at once by the addition of any ferment. This seems to be the reason why the Tartars, who make a fermented liquor, or wine, from mare's milk, called *koumiss*, succeed by using large quantities at a time, and agitating it very frequently. They add as a ferment a sixth part of water, and an eighth part of the sourest cow's milk they can get, or a smaller portion of koumiss already prepared: cover the vessel with a thick cloth, and let it stand in a moderate warmth for 24 hours: then beat it with a stick, to mix the thicker and thinner parts, which have separated: let it stand again 24 hours in a high narrow vessel, and repeat the beating, till the liquor is perfectly homogeneous. This liquor will keep some months, in close vessels, and a cold place; but must be well mixed by beating or shaking every time it is used. They sometimes extract a spirit from it by distillation. The Arabs prepare a similar liquor by the name of *lebam*, and the Turks by that of *yaourt*. Eton informs us, that, when properly prepared, it may be left to stand till it becomes quite dry; and in this state it is kept in bags, and mixed with water when wanted for use.

The saccharine substance, upon which the fermenting property of milk depends, is held in solution by the whey, which remains after the separation of the curd in making cheese. This is separated by evaporation in the large way, for pharmaceutical purposes, in various parts of Switzerland. When the whey has been evaporated by heat, to the consistence of honey, it is poured into proper moulds, and exposed to dry in the sun. If this crude sugar of milk be dissolved in water, clarified with whites of eggs, and evaporated to the consistence of syrup, white crystals, in the form of rhomboidal parallelopipedons, are obtained.

Sugar of milk has a faint saccharine taste, and is soluble in three or four parts of water. It yields by distillation the same products that other sugars do, only in somewhat different proportions. It is remarkable, however, that the empyreumatic oil has a smell resembling flowers of benzoin. It contains an acid frequently called the saccholactic; but as it is common to all mucilaginous substances, it has been termed mucic. See ACID (MUCIC).

The kinds of milk that have been chemically examined, are mare's, woman's, ass's, goat's, sheep's, and cow's. We have here placed them according to the proportion of *sugar* they afforded; and this, Parmentier observes, was precisely of the same quality in all, while all the other parts varied in quality as well as quantity in the different milks. With regard to the *whey*, they rank in the following order: ass's, mare's, woman's, cow's, goat's, sheep's: to *cream*; sheep's, woman's, goat's, cow's, ass's, mare's: to *butter*; sheep's, goat's, cow's, woman's: to *cheese*; sheep's, goat's, cow's, ass's, woman's, mare's. Parmentier could not make any butter from the cream of woman's, ass's, or mare's milk; and that from sheep he found always remained soft. From their general properties, he has divided them into two classes, one abounding in serous and saline parts, which includes ass's, mare's, and woman's; the other rich in caseous and butyraceous parts, which are cow's, goat's, and sheep's.

Cream, sp. gr. 1.0244 by Berzelius's analysis, consists of butter 4.5, cheese 3.5, whey 92. Curd, by the analysis of MM. Gay Lussac and Thenard, is composed of

Carbon,	59.781
Oxygen,	11.400
Hydrogen,	7.429
Azote,	21.381
	100.000

Whey always reddens vegetable blues, from the presence of lactic acid. Milk, according to Berzelius, consists of,

Water, - - - - -	928.75
Curd, with a little cream, -	28.00
Sugar of milk, - -	35.00
Muriate of potash, - -	1.70
Phosphate of potash, -	0.25

Earthy phosphates, - -	0.30
	1000.00

Since both cream and water affect the specific gravity of milk alike, it is not possible to infer the quality of milk from the indications merely of a specific gravity instrument. We must first use as a lactometer a graduated glass tube, in which we note the thickness of the stratum of cream afforded, after a proper interval, from a determinate column of new milk. We then apply to the skimmed milk a hydrometric instrument, from which we learn the relative proportions of curd and whey. Thus, the combination of the two instruments furnishes a tolerably exact lactometer.

MILK QUARTZ. See Quartz.

MILT of the Carp. It contains, according to Fourcroy and Vauquelin, albumen, gelatin, phosphorus, phosphate of lime, phosphate of magnesia, and muriate of ammonia.

MINDERERUS' SPIRIT. Liquid acetate of ammonia.

MINERALOGY. That department of natural history which teaches us to describe, recognize, and classify, the different genera and species of the objects of inorganic nature. As the greater part of these are solids, extracted from the earth by mining, they are called Minerals. The term Fossil is now commonly restricted to such forms of organic bodies as have been penetrated with earthy or metallic matters.

Professor Mohs of Freyberg has lately published a work, replete with profound general views on mineralogy, which promises to place the science on a surer basis than it has hitherto stood.

Werner first taught mineralogists to consider the productions of inorganic nature in a state of mutual connexion, resulting from mineralogical similarity. Thus, heavy spar is plainly more similar to calcareous spar than felspar is; felspar than garnet; garnet than iron-glance; iron-glance than native gold; and so on.

A collection of species connected by the *highest*, and at the same time equal degrees of natural-history similarity, is named a *genus*. The same occurs in zoology and botany. Thus, the wolf, dog, fox; the lion, tiger, cat, unite into genera. Individuals whose forms belong to two different systems of crystallizations cannot be united in the same species. Radiated hepatic, and cristated iron pyrites, therefore, constitute a distinct species. Yet this species is so similar to that of common iron pyrites (tessular), that we must unite them into one genus.

An order comprehends several analogous genera; and a class, analogous orders.

The specific character consists particularly talline forms may be reduced in all cases to one of *four* Systems of Crystallization: the Rhombohedral; the Pyramidal, derived from a four-sided isosceles pyramid; the Prismatic, derived from a scalene four-sided pyramid; and lastly the Tessular, or that which is derived from the hexahedron.

When we wish to determine the species to which any mineral belongs, by means of a tabular view, we must first ascertain either its primitive form or cleavage, and afterwards the hardness and specific gravity. The degrees of hardness are expressed by Mohs in the following manner:—

1 expresses the hardness of	Talc,
2	Gypsum,
3	Calcareous spar,
4	Fluor spar,
5	Apatite,
6	Felspar,
7	Quartz,
8	Topaz,
9	Corundum,
10	Diamond.

Professor Mohs has arranged minerals into three classes.

I. Character of the first class.

If solid; sapid. No bituminous odour. Sp. gr. under 3.8. It has 4 orders.

Order 1. *Gas.* Expansible. Not acid.

2. *Water.* Liquid. Without odour or sapidity. Sp. gr. 1.

3. *Acid.* Acid. Specific gravity, 0·0015 to 3·7.

4. *Salt.* Not acid. Sp. gr. 1·2 to 2·9.

II. Character of the second class.

Insipid. Sp. gr. above 1·8.

Order 1. *Haloide* (salt-like). Not metallic. Streak uncoloured.

If pyramidal or prismatic; H. hardness = 4 and less. If tessular, H. = 4.0. If single, perfect, and eminent faces of cleavage; sp. gr. = 2·4 and less.

H. = 1·5 to 5·0. If under 2·5, sp. gr. = 2·4 and less. Sp. gr. = 2·2 to 3·3. If 2·4 and less, H. under 2·5; and no resinous lustre.

Order 2. *Baryte.*

Not metallic. If adamantine or imperfec metallic lustre; sp. gr. = 6.0 and more. Streak uncoloured, or orange-yellow. If orange-yellow; sp. gr. = 6.0 and more, and H. = 3.0 and less.

H. = 2·5 to 5·0. If 5·0; sp. gr. under 4·5.

Sp. gr. = 3·3 to 7·2. If under 4·0 and H. = 5·0; cleavage diprismatic.

Order 3. *Kerate* (Horny).

Not metallic. Streak uncoloured. N.

single eminent cleavage. H. = 1·0 to 2·0. Sp. gr. = 5·5.

Order 4. *Malachite.*

Not metallic. Colour blue, green, brown. If brown colour of streak; H. = 3·0 and less; and sp. gr. above 2·5. If uncoloured streak; sp. gr. = 2·2 and less; and H. = 3·0. No single eminent faces of cleavage. H. = 2·0 to 5·0. Sp. gr. = 2·0 to 4·6.

Order 5. *Mica.*

If metallic; Sp. gr. under 2·2. If not metallic; sp. gr. above 2·2. If yellow streak; pyramidal. Single eminent cleavage. H. = 1·0 to 4·5. If above 2·5; rhombohedral. Sp. gr. = 1·8 to 5·6. If under 2·5; metallic. If above 4·4; streak uncoloured.

Order 6. *Spar.*

Not metallic. Streak uncoloured, brown. If rhombohedral; sp. gr. 2·2 and less, or H. = 6·0.

H. = 3·5 to 7. If 4·0 and less; single eminent cleavage. If above 6·0; sp. gr. under 2·5, or above 2·8; and pearly lustre. Sp. gr. = 2·0 to 3·7. If above 3·3; hemi-prismatic, or H. = 6·0; and no adamantine lustre. If 2.4 and less; not without traces of form and cleavage.

Order 7. *Gem.*

Not metallic. Streak uncoloured. H. = 5·5 to 10. If 6·0 and less; sp. gr. = 2·4 and less; and no traces of form and cleavage. Sp. gr. = 1·9 to 4·7. If under 3·8; no pearly lustre.

Order 8. *Ore.*

If metallic; black. If not metallic; adamantine, or imperfect metallic lustre. If yellow or red streak; H. = 3.5 and more; and sp. gr. = 4.8 and more. If brown or black streak; H. = 5·0 and more, or perfectly prismatoidal. H. = 2·5 to 7·0. If 4·5 and less; red, yellow, or black streak. If 6·5 and more; and streak uncoloured; sp. gr. = 6.5 and more. Sp. gr. = 3·4 to 7·4.

Order 9. *Metal.*

Metallic. Not black. If gray; malleable; and sp. gr = 7·4 and more. H. = 0·0 to 4·0 or malleable. Sp. gr. = 5·7 to 20·0.

Order 10. *Pyrites.*

Metallic. H. = 3·5 to 6·5. If 4·5 and less; sp. gr. under 5·0. Sp. gr. = 4·1 to 7·7. If 5·3 and less; colour yellow or red.

Order 11. *Glance.*

Metallic. Gray, black. H. 1·0 to 4·0. Sp. gr. = 4·0 to 7·6. If under 5·0, and single perfect cleavage, lead-gray. If above 7·4; lead gray.

Order 12. *Blende.*

If metallic; black. If not metallic; adamantine lustre. If brown streak; uncoloured. Sp. gr. between 4·0 and 4·2; and the form, tessular. If red streak; sp. gr. = 4·5 and more; and H. = 2·5 and less.

H. = 1·0, 4·0. Sp. gr. = 3·9, 8·2. If 4·3 and more; streak red.

Order 13. *Sulphur.*

Not metallic. Colour red, yellow, or brown. Prismatic. H. = 1·0 to 2·5. Sp. gr. = 1·9 to 3·6. If above 2·1; streak yellow, or red.

Class III.

If fluid; bituminous odour. If solid; insipid. Sp. gr. under 1·8.

Order 1. *Resin.*

Fluid, solid. Streak uncoloured, yellow, brown, black. H. = 0·0 to 2·5. Sp. gr. = 0·7 to 1·6. If 1·2 and more; streak uncoloured.

Order 2. *Coal.*

Solid. Streak, brown, black. H. = 0·1 to 2·5. Sp. gr. = 1·2 to 1·5.

Genera.

Class I. Order 1. *Gas.*

Genera. 1. Hydrogen. 2. Atmospheric air.

Order 2. *Water.*

Genus. 1. Atmospheric water.

Order 3. *Acid.*

Genera. 1. Carbonic. 2. Muriatic. 3. Sulphuric. 4. Boracic; and 5. Arsenic.

Order 4. *Salt.*

Genera. 1. Natron-salt. 2. Glauber-salt. 3. Nitre-salt. 4. Rock-salt. 5. Ammoniac-salt. 6. Vitriol-salt; comprising as species, the sulphates of iron, copper, and zinc. 7. Epsom-salt. 8. Alum-salt. 9. Borax-salt. 10. Barythine-salt (heavy-salt). Glauberite.

Class II. Order 1. *Haloide.*

Genera. 1. Gypsum-haloide. 2. Cryone-haloide. 3. Alum-haloide. 4. Fluor-haloide. 5. Calc-haloide.

Order 2. *Baryte.*

Genera. 1. Parachrose-baryte (altered colour). 2. Zinc-baryte. 3. Scheelium-baryte. 4. Hal-baryte. 5. Lead-baryte.

Order 3. *Kerate.*

Genera. 1. Pearl-kerate.

Order 4. *Malachite.*

Genera. 1. Staphyline-malachite (grape like). 2. Lirocone-malachite (form unknown). 3. Olive malachite. 4. Azure-malachite. 5. Emerald-malachite. 6. Habroneme-malachite (fine threaded).

Order 5. *Mica.*

Genera. 1. Euchlore-mica (bright green). 2. Antimony-mica. 3. Cobalt-mica. 4. Iron-mica. 5. Graphite-mica. 6. Talc-mica. 7. Pearl-mica.

Order 6. *Spar.*

Genera. 1. Schiller-spar. 2. Disthene-spar. 3. Triphane-spar. 4. Dystome-spar (difficult to cleave). 5. Kouphone-spar (light). 6. Petaline-spar. 7. Felspar. 8. Augite-spar. 9. Azure-spar.

Order 7. *Gem.*

Genera. 1. Andalusite. 2. Corundum. 3. Diamond. 4. Topaz. 5. Emerald. 6. Quartz. 7. Axinite. 8. Chrysolite. 9. Boracite. 10. Tourmaline. 11. Garnet. 12. Zircon. 13. Gadolinite.

Order 8. *Ore.*

Genera. 1. Titanium-ore. 2. Zinc-ore. 3. Copper-ore. 4. Tin-ore. 5. Scheelium-ore. 6. Tantalum-ore. 7. Uranium-ore. 8. Cerium-ore. 9. Chrome-ore. 10. Iron-ore. 11. Manganese-ore.

Order 9. *Metal.*

Genera. 1. Arsenic. 2. Tellurium. 3. Antimony. 4. Bismuth. 5. Mercury. 6. Silver. 7. Gold. 8. Platina. 9. Iron. 10. Copper.

Order 10. *Pyrites.*

Genera. 1. Nickel-pyrites. 2. Arsenic-pyrites. 3. Cobalt-pyrites. 4. Iron-pyrites. 5. Copper-pyrites.

Order 11. *Glance.*

Genera. 1. Copper-glance. 2. Silver-glance. 3. Lead-glance. 4. Tellurium-glance. 5. Molybdena-glance. 6. Bismuth-glance. 7. Antimony-glance. 8. Melane-glance (black).

Order 12. *Blende.*

Genera. 1. Glance-blende. 2. Garnet-blende. 3. Purple-blende. 4. Ruby-blende.

Order 13. *Sulphur.*

1. Sulphur.

Class III. Order 1. *Resin.*

Genus. Melichrone-resin (honey-coloured).

Order 2. *Coal.*

Genus. Mineral-coal.

Such are the genera of Professor Mohs. I would willingly have introduced a view of the species; but his symbols of their crystalline structure, and forms, would require a detailed explanation, inconsistent with the limits of this work. An account of his new system of crystallography is given by one of his pupils in the 3d vol. of the Edin. Phil. Journal. But the Professor promises soon to publish that system himself; which, if we may judge from the luminous exposition of the *characteristic of his* Natural History System, recently published, will be a great acquisition to mineralogical science. This has been ably translated into English by M. Haidinger, himself an excellent mineralogist.

MINERAL CAOUTCHOUC. See Caoutchouc.

MINERAL CHARCOAL. See Charcoal (Mineral).

MINERAL OIL. See Petroleum.

MINERAL PITCH. See Bitumen.

MINERALIZER. Metallic substances are said to be mineralized when deprived of their usual properties by combination with some other substance.

MINER'S SAFETY LAMP. See Lamp.

MINIUM. Red oxide of lead.

MIRRORS. See Speculum; also Silvering.

MISPICKEL. Arsenical pyrites.

MOCHA-STONE. See Agate.

MOIREE METALLIQUE. When we pour on heated tin-plate a mixture of 2 parts of the nitric acid of commerce, and 3 of muriatic acid diluted with 8 of water, we obtain, after washing, a beautiful crystalline surface, in plumose forms, which was first observed a few years ago by M. Alard. It is usually called in this country crystallized tin-plate; and, when varnished, it is worked into ornamental vessels. The figures vary, according to the degree of heat previously given to the metal.

MOLYBDATE OF LEAD. See Ores of Lead.

MOLYBDENUM. A metal which has not yet been reduced into masses of any magnitude; but has been obtained only in small separate globules, in a blackish brilliant mass. This may be effected by making its acid into a paste with oil, bedding it in charcoal in a crucible, and exposing it to an intense heat. The globules are gray, brittle, and extremely infusible. By heat it is converted into a white oxide, which rises in brilliant needle-formed flowers, like those of antimony. Nitric acid readily oxidizes and acidifies the metal. Nitre detonates with it, and the remaining alkali combines with its oxide.

Molybdenum unites with several of the metals, and forms brittle or friable compounds. No acid acts on it but the nitric and nitromuriatic. Several acids act on its oxide, and afford blue solutions. See Acid (Molybdic).

The sp. gr. of molybdenum is 8·611. When dry molybdate of ammonia is ignited in a crucible with charcoal powder, it is converted into the brown oxide of the metal. This has a crystallized appearance, a copper-brown colour, and a sp. gr. of 5·66. It does not form salts with acids. The deutoxide is molybdous acid, which see.

MONTMARTRITE. Its colour is yellowish; it occurs massive, but never crystallized. It is soft. It effervesces with nitric acid. It is a compound of 83 sulphate of lime, and 17 carbonate of lime, which is found at Montmartre, near Paris. It stands the weather, which common gypsum does not bear.

MOONSTONE. A variety of adularia.

MOOR-COAL. See Coal.

MORASS-ORE. Bog-iron ore.

MORDANT. In dyeing, the substance combined with the vegetable or animal fibre, in order to fix the dye-stuff. It also usually modifies the colour. See Dyeing.

MOROXYLATES. Compounds of moroxylic acid with the salifiable bases.

MOROXYLIC ACID. See Acid (Moroxylic).

MOROXITE. *Apatite* of a blue-green colour from Norway.

MORPHIA. A new vegetable alkali,

extracted from opium, of which it constitutes the narcotic principle. It was first obtained pure, by M. Sertürner, about the year 1817.

Two somewhat different processes for procuring it have been given by M. Robiquet and M. Choulant.

According to the former, a concentrated infusion of opium is to be boiled with a small quantity of common magnesia for a quarter of an hour. A considerable quantity of a grayish deposite falls. This is to be washed on a filter with cold water, and when dry, acted on by weak alcohol for some time, at a temperature beneath ebullition. In this way very little morphia, but a great quantity of colouring matter, is separated. The matter is then to be drained on a filter, washed with a little cold alcohol, and afterwards boiled with a large quantity of highly rectified alcohol. This liquid being filtered while hot, on cooling it deposits the morphia in crystals, and very little coloured. The solution in alcohol, and crystallization, being repeated two or three times, colourless morphia is obtained.

The theory of this process is the following: Opium contains a meconiate of morphia. The magnesia combines with the meconic acid, and the morphia is displaced.

Choulant directs us to concentrate a dilute watery infusion of opium, and leave it at rest till it spontaneously let fall its sulphate of lime in minute crystals. Evaporate to dryness; redissolve in a little water, and throw down any remaining lime and sulphuric acid, by the cautious addition, first of oxalate of ammonia, and then of muriate of barytes. Dilute the liquid with a large body of water, and add caustic ammonia to it, as long as any precipitate falls. Dissolve this in vinegar, and throw it down again with ammonia. Digest on the precipitate about twice its weight of sulphuric ether, and throw the whole upon a filter. The dry powder is to be digested three times in caustic ammonia, and as often in cold alcohol. The remaining powder being dissolved in twelve ounces of boiling alcohol, and the filtered hot solution being set aside for 18 hours, deposits colourless transparent crystals, consisting of double pyramids. By concentrating the supernatant alcoholic solution, more crystals may be obtained.

The following process of M. Hottot is much commended.

Opium is to be dissolved in so much water as to yield a solution of a specific gravity not higher than 1·012. A small quantity of ammonia is then to be added, just sufficient to precipitate the colouring matter of the solution. In consequence of the diluted state of the liquor this readily falls to the bottom. The clear solution is then removed, and more ammonia added to it to precipitate the morphia. The vegetable alkali separates, and falls on standing, as a crystalline sediment, containing very little colouring matter. This washed with cold water, and afterwards treated with alcohol, sp. gr. 0·840, and a little animal charcoal, gives by the first operation, a morphia so pure as to require no further solution in alcohol, or union with sulphuric acid. By this process a considerable quantity of morphia may be obtained in 24 hours, with very little waste of alcohol. The only point to be attended to, is to separate carefully the fatty matter which falls in the first instance, on adding a small quantity of ammonia, so that it may not be redissolved by the addition of the further quantity of ammonia necessary to throw down the morphia.

The product by the magnesia process was rarely so white and pure as that of the above method; nor was the quantity so great. *Journal de Pharm.* x. 475.

M. Choulant says, it crystallizes in double four-sided pyramids, whose bases are squares or rectangles. Sometimes in prisms with trapezoidal bases.

It dissolves in 82 times its weight of boiling water, and the solution on cooling deposits regular, colourless, transparent crystals. It is soluble in 36 times its weight of boiling alcohol, and in 42 times its weight of cold alcohol, of 0·92. It dissolves in eight times its weight of sulphuric ether. All these solutions change the infusion of brazil-wood to violet, and the tincture of rhubarb to brown. The saturated alcoholic and ethereous solutions, when rubbed on the skin, leave a red mark.

Sulphate of morphia crystallizes in prisms, which dissolve in twice their weight of distilled water. They are composed of

Acid,	22	5·00
Morphia,	40	9·09
Water,	38	
	100	

Nitrate of morphia yields needle-form crystals in stars, which are soluble in 1½ times their weight of distilled water. Its constituents are,

Acid,	20	6·75
Morphia,	36	12·15
Water,	44	
	100	

Muriate of morphia is in feather-shaped crystals, and needles. It is soluble in 10½ times its weight of distilled water. Its constituents are,

Acid,	35	4·625
Morphia,	41	5·132
Water,	24	
	100	

The acetate crystallizes in needles; the tartrate in prisms; and the carbonate in short

Oxygen,	0·4917
	1·0000

from the analysis of one grain, by ignited peroxide of copper. He imagines the atom to be either 40·25, or 20·125.

MM. Dumas and Pelletier, in their extensive memoir on organic salifiable bases, observe on morphia, that Dr. Thomson's results are affected by some inaccuracy proceeding undoubtedly from the analytical method which he employed; for M. Bussy, of the school of pharmacy, had lately published a well-conducted analysis of morphia, in which he found azote, a principle which Dr. Thomson had not supposed to exist in it. M. Bussy shows also a much larger proportion of carbon, as we may perceive, by comparing his results with the preceding.

Carbon, . . .	69·0
Hydrogen, . .	6·5
Azote, . . .	4·5
Oxygen, . .	20·0
	100·0

MM. Dumas and Pelletier made the ultimate analysis of morphia on two very pure specimens extracted by different methods. The mean of the two results, which differed very little, and which they regard as very exact, was,

Carbon, . .	72·02
Hydrogen, .	7·61
Azote, . .	5·53
Oxygen, . .	14·84
	100·00

Ann. de Chim. xxiv. 184.

Mr. Brande's analysis gives, as the mean of three experiments;

Carbon, . .	72·00
Hydrogen, . .	5·50
Azote, . . .	5·50
Oxygen, . .	17·00
	100·00

Journal of Science, xvi. 284.

The near coincidence of these analytical results, places the errors of Dr. Thomson's in a very strong light.

The prime equivalent of morphia seems to be about 40 by Pelletier and Caventou, which is probably more exact than the number deducible from Choulant.

Tincture of galls is said to be a good test of morphia free or combined.

Subacetate of lead throws down all the animal matters with which acetate of morphia may come to be associated in the stomach, without acting on that vegetable salt. The

red colour which nitric acid imparts to it. No morphia is found in the blood of animals killed with it. *Ann. de Chimie*, xxv. 105.

Morphia acts with great energy on the animal economy. A grain and a half taken at three different times, produced such violent symptoms upon three young men of 17 years of age, that Sertürner was alarmed lest the consequences should have proved fatal.

Morphia, according to its discoverer, melts in a gentle heat; and in that state has very much the appearance of melted sulphur. On cooling, it again crystallizes. It burns easily; and when heated in close vessels, leaves a solid resinous black matter, having a peculiar smell.

MORTAR CEMENT. A mixture of lime and siliceous sand, used in masonry for cementing together the stones and bricks of a building. The most precise ideas which we have on this subject were given by Sir H. Davy in his Agric. Chem. See LIME and CEMENT.

MOSAIC GOLD. See AURUM MUSIVUM.

MOTHER OF PEARL shells are composed of alternate layers of coagulated albumen and carbonate of lime, in the proportion, by Mr. Hatchett, of 24 of the former and 76 of the latter, in 100 parts.

MOTHER WATER. When sea-water, or any other solution containing various salts, is evaporated, and the crystals taken out; there always remains a fluid containing deliquescent salts, and the impurities, if present. This is called the mother water.

MOULD. See SOIL, MANURE, and ANALYSIS (VEGETABLE).

MOUNTAIN BLUE. Malachite; carbonate of copper.

MOUNTAIN CORK and MOUNTAIN LEATHER. See ASBESTUS.

MOUNTAIN GREEN. Common copper green; a carbonate of copper.

MOUNTAIN or ROCK WOOD. See ASBESTUS.

MOUNTAIN SOAP. Colour pale brownish-black. Massive. Dull. Fracture fine earthy. Opaque. Streak shining. Writes, but does not soil. Soft. Sectile. Easily frangible. Adheres strongly to the tongue. Feels very greasy. It is light, bordering on rather heavy. It occurs in trap rocks in the island of Skye. It is used in crayon-painting.

MOUNTAIN TALLOW. See TALLOW.

MUCILAGE. An aqueous solution of gum.

MUCUS. This, according to Dr. Bostock, is one of the primary animal fluids, perfectly distinct from gelatin.

The subacetate of lead does not affect gelatin; on the other hand, tannin, which is a delicate test of gelatin, does not affect mucus. Both these reagents, however, precipitate albumen; but the bichloride of mercury, which will indicate the presence of albumen dissolved in 2000 parts of water, precipitates neither mucus nor gelatin. Thus we have three distinct and delicate tests for these three different principles.

Gum appears to resemble mucus in its properties. One grain of gum-arabic, dissolved in 200 of water, was not affected by bichloride of mercury, or by tannin, but was immediately precipitated by subacetate of lead.

MUFFLE. A small earthen oven, made and sold by the crucible manufacturers. It is to be fixed in a furnace, and is useful for cupellation, and other processes which demand access of air.

MULLER'S GLASS. Hyalite.

MURIACITE. Gypsum.

MURIATIC ACID. See Acid (Muriatic).

MURICALCITE. Rhomb-spar.

MUSCLES OF ANIMALS. See Fibrin and Flesh.

MUSCOVY GLASS. Mica.

MUSHROOMS. See Boletus.

MUSSITE. Diopside.

MUST. The juice of grape, composed of water, sugar, jelly, gluten, and bitartrate of potash. From a French wine pint of *must*, the Marquis de Bullion extracted half an ounce of sugar, and 1-16th of an ounce of tartar. Proust says, the muscadine grape contains about 30 per cent. of a peculiar species of sugar. By fermentation it forms wine.

MYRICIN. The ingredient of wax which remains after digestion with alcohol. It is insoluble likewise in water and ether; but very soluble in fixed and volatile oils. Its melting point is about 120°. Sp. gr. 0·90. Its consistence is waxy.

MYRRH. A gum resin, which consists, according to Braconnot, of

Resin, containing some volatile oil,	33·68
Gum, ...	66·32
	100·00

N

NACRITE. See Talcite.

NADLESTEIN. Rutile.

NAILS, consist of coagulated albumen, with a little phosphate of lime.

NANKIN DYE. See Iron, towards the end.

NAPHTHA. A native combustible liquid, of a yellowish-white colour, perfectly fluid and shining. It feels greasy, exhales an agreeable bituminous smell, and has a specific gravity of about 0·7. It takes fire on the approach of flame, affording a bright white light. It occurs in considerable springs on the shores of the Caspian Sea, in Sicily and Italy. It is used instead of oil, and differs from the petroleum obtained by distilling coal tar, only by its greater purity and lightness. By Dr. Thomson's recent analysis of a specimen of naphtha from Persia, whose sp. gr. was 0·753, and boiling point 320°, it appears to be composed of carbon 82·2 + hydrogen 14·8, with perhaps a little azote.

By my analysis, naphtha, specific gravity 0.857, boiling point 316° Fahr., contains in 100, carbon 83.04, hydrogen 12.31, oxygen 4.65; which is very nearly

Carbon,	22 atoms	16.5	82.5
Hydrogen,	20 —	2.5	12.5
Oxygen,	1 —	1.0	5.0

It is therefore resolvable into 20 atoms of olefiant gas, 1 atom carbonic oxide holding 1 atom of carbon in combination.—*Phil. Trans.* 1822.

NAPHTHALINE. A grayish-white substance found during the rectification of the petroleum of the coal gas works, incrusting the pipes. It may be obtained in thin white scales of a pearly brightness, by slow resublimation in glass vessels. Its spec. grav. is 1.048. It has a strong odour of naphtha. It is insoluble in water, but very soluble in ether, and moderately so in alcohol and oils. In water heated to 168° Fahr. it fuses, and remains at the bottom of the liquid, but when stirred it rises, and spreads on the top in oily patches. At 180° it rises spontaneously from the bottom in oily looking globules, which, as the temperature is raised, dissipate in the air, undergoing motions similar to those of camphor floating on water. Naphthaline is, according to my analysis, a solid bicarburet of hydrogen, consisting of

Carbon,	2 atoms	1·5	92·9
Hydrogen,	1 —	0·125	7·1
		1·625	100·0

—*Phil. Trans.* 1822.

NAPLES YELLOW. According to Professor Beckmann, this colour is prepared by calcining lead with antimony and potash in a reverberatory furnace.

NATRON. Native carbonate of soda, of which there are two kinds, the common and radiated. See Soda.

NATROLITE. A sub-species of prismatic zeolite or mesotype. Colour yellowish. Massive, in plates and reniform. Seldom becomes first black, then red, intumesces, and melts into a white compact glass. Its constituents are, silica 48.0, alumina 24.25, natron 16.5, oxide of iron 1.75, and water 9. It occurs in chalkstone porphyry in Wurtemberg and Bohemia, and in the trap-tuff hill named the Bin, behind Burntisland, in Scotland.

NECROMITE. A mineral found near Baltimore, in small masses, of a white colour, in limestone. It possesses a disagreeable odour.

NEEDLE ORE. Acicular bismuth glance.

NEEDLE ZEOLITE. Colour grayish-white. Massive; in distinct concretions; and crystallized in acicular rectangular four-sided prisms, variously acuminated and truncated. The lateral planes are longitudinally streaked. Glistening, inclining to pearly. Cleavage twofold, in the direction of the lateral plane of the prism. Translucent. Refracts double. As hard as apatite. Brittle. Spec. grav. 2.3. It intumesces before the blowpipe, and forms a jelly with acids. It becomes electric by heating, and retains this property some time after it has cooled. The free extremity of the crystal, with the acumination, shows positive, and the attached end negative electricity. Its constituents are, silica 50.24, alumina 29.3, lime 9.46, water 10. It occurs in secondary trap rocks near the village of Old Kilpatrick in Scotland.

NEPHELINE. Rhomboidal felspar. Colour white. Massive and crystallized. The primitive form is a dirhomboid of 152° 44′, and 56° 15′. The secondary forms are, a perfect equiangular six-sided prism; the same truncated on the terminal edges; and a thick six-sided table, with the lateral edges all truncated. The crystals form druses. Lustre splendent, vitreous. Cleavage fourfold. Fracture conchoidal. Translucent and transparent. As hard as felspar. Spec. grav. 2.6 to 2.7. It melts with difficulty before the blowpipe. Its constituents are silica 46, alumina 49, lime 2, oxide of iron 1. It occurs in drusy cavities, along with ceylanite, vesuvian, and meionite, at Monte Somma, near Naples, in drusy cavities, in granular limestone.

NEPHRITE. Of which mineral there are two kinds; common nephrite and axe-stone.

Common nephrite. Colour leek-green. Massive and in rolled pieces. Dull. Fracture coarse splintery. Translucent. Nearly as hard as rock-crystal. Difficultly frangible. Feels rather greasy. Rather brittle. Spec. grav. 3. It melts before the blowpipe into a white enamel. Its constituents are, silica 50.5, magnesia 31, alumina 10, iron 5.5, chrome 0.05, water 2.75. Nephrite occurs in and Egypt. The South American variety is called Amazon stone, from its locality. See Axe Stone.

NERIUM TINCTORIUM. A tree growing in Hindostan, which, according to Dr. Roxburgh, affords indigo.

NEUTRALIZATION. When acid and alkaline matter are combined in such proportions that the compound does not change the colour of litmus or violets, they are said to be neutralized.

NICKEL is a metal of great hardness, of an uniform texture, and of a colour between silver and tin; very difficult to be purified, and magnetical. It even acquires polarity by the touch. It is malleable, both cold and red-hot; and is scarcely more fusible than manganese. Its oxides, when pure, are reducible by a sufficient heat without combustible matter; and it is little more tarnished by heating in contact with air, than platina, gold, and silver. Its spec. grav. when cast, is 8.279; when forged, 8.666.

Nickel is commonly obtained from its sulphuret, the kupfernickel of the Germans, in which it is generally mixed also with arsenic, iron, and cobalt. This is first roasted, to drive off the sulphur and arsenic, then mixed with two parts of black flux, put into a crucible, covered with muriate of soda, and heated in a forge furnace. The metal thus obtained, which is still very impure, must be dissolved in dilute nitric acid, and then evaporated to dryness; and after this process has been repeated three or four times, the residuum must be dissolved in a solution of ammonia, perfectly free from carbonic acid. Being again evaporated to dryness, it is now to be well mixed with two or three parts of black flux, and exposed to a violent heat in a crucible for half an hour or more.

According to Richter, the oxide is more easily reduced, by moistening with a little oil. Thenard advises to pour chloride of lime on the oxide of nickel, and shake them well together, before the ammonia is added; as thus the oxides of cobalt and iron, if present, will be so much saturated with oxygen as to be insoluble in the ammonia, and consequently may be separated.

M. Chenevix observed, that a very small portion of arsenic prevents nickel from being affected by the magnet. Richter found the same. When it is not attractible, therefore, we may be pretty certain that this is present. To separate the arsenic, M. Chenevix boiled the compound in nitric acid, till the nickel was converted into an arseniate; decomposed this by nitrate of lead, and evaporated the liquor, not quite to dryness. He then poured in alcohol, which dissolved only the nitrate of nickel. The alcohol being decanted and be perfectly magnetic; but this property was destroyed again, by alloying the metal with a small portion of arsenic. Alloying it with copper weakens this property.

Nickel and cobalt being usually associated, it becomes an important problem to separate them. See COBALT, *et infra.*

There are two oxides of nickel; the dark ash-gray, and the black. If potash be added to the solution of the nitrate or sulphate, and the precipitate dried, we obtain the protoxide. It may be regarded as a compound of about 100 metal with 28 of oxygen; and the prime equivalent of the metal will become 3.6, while that of the protoxide will be 4.6. The peroxide was formed by Thenard, by passing chlorine through the protoxide diffused in water. A black insoluble peroxide remains at the bottom.

The compounds of nickel have been made the subject of experiment by M. Lassaigne.

Protoxide of nickel. A given weight of pure nickel was dissolved in pure nitric acid, evaporated to dryness, and decomposed by heat. It was of a gray colour, soluble in acids, precipitated by alkalis, as a hydrate, &c. Composition,

Nickel, . . .	100
Oxygen, . . .	20

Deutoxide of nickel. Obtained by diffusing hydrate of nickel in water, and passing a current of chlorine through it. One part is dissolved, and the other becomes peroxide. It is of a brilliant black colour; heated, it loses oxygen, and becomes protoxide. Acids dissolve it, liberating oxygen, except muriatic, which disengages chlorine. Its composition, ascertained by its loss of weight when heated, appeared to be

Nickel, . . .	100
Oxygen, . . .	39·44;

whence the prime equivalent of nickel seems to be 5, on the oxygen scale.

Sulphuret of nickel, prepared directly from its elements, is of a yellow colour, like iron pyrites, and very brittle. It was analyzed by calcination with nitre. Composition,

Nickel, . . .	100
Sulphur, . . .	41·3

Chloride of nickel, prepared by evaporating the muriate to dryness. It is of a yellow-green colour, and is a protochloride. Composition,

Nickel, . . .	100
Chlorine, . . .	90

When the above chloride is calcined in a retort, one portion of an olive-green colour remains in the bottom of the vessel, while another sublimes, and crystallizes in small light brilliant plates of a gold-yellow colour. These are the deutochloride, consisting of

Iodide of nickel... fusible; soluble in water, colouring it of a light green; and composed of

Nickel, . . .	100
Iodine, . . .	320

—*Ann. de Chimie*, xxi. 255.

M. Berthier has given the following as an economical way of preparing pure nickel. Speiss, or the impure nickel of commerce, is to be reduced into fine powder, and roasted until it gives off no farther vapours of arsenic, the heat being at first moderate, to prevent fusion, and then increased. Metallic iron in the state of filings, or nails, is to be added in a quantity which ought to be previously determined, and the whole dissolved in boiling nitro-muriatic acid, so much nitric acid being used that no protoxide of iron shall remain in the solution; evaporate to dryness, and redissolve in water, when a large quantity of arseniate of iron will be left. Add to the solutions successive portions of carbonate of soda, until a greenish precipitate appears, at which time all the arsenic and iron will be separated, and part of the copper; the rest of the copper may be separated by sulphuretted hydrogen, and the clear solution thus obtained, when boiled with carbonate of soda, yields the carbonate of nickel.

Thus obtained, the carbonate of nickel contains a little cobalt. To separate the latter, the precipitate as obtained above, by boiling with carbonate of soda, is to be well washed and diffused while moist in water, and a current of chlorine in excess passed into it. The excess of chlorine is to be allowed to dissipate, and the solution is to be filtered. It now contains not the smallest trace of cobalt, which metal remains as a hydrated peroxide with a certain portion of nickel in the same state.—*Ann. de Chimie*, xxv. 95.

A compound, resembling meteoric iron, has been made, by fusing together about 5 or 10 parts of nickel with 95 or 90 of iron. The meteoric iron from Baffin's Bay contains 3 per cent. of nickel, the Siberian contains 10 per cent., by Mr. Children's analysis.—*See Journal of Science*, vol. ix.

The salts of nickel possess the following general characters. They have usually a green colour, and yield a white precipitate with ferroprussiate of potash. Ammonia dissolves the oxide of nickel. Sulphuretted hydrogen and infusion of galls occasion no precipitate. The hydrosulphuret of potash throws down a black precipitate. Their composition has been very imperfectly ascertained.

The sulphuric and muriatic acids have little action upon nickel. The nitric and nitro-muriatic are its most appropriate solvents. The nitric solution is of a fine grass-green colour. Carbonate of potash throws down from blackish-gray, barely inclining to green, and weighing only 1.285. By continuing the fire it is reduced.

When ammonia is added in excess to a nitric solution of nickel, a blue precipitate is formed, which changes to a purple-red in a few hours, and is converted to an apple-green by an acid. If the precipitate retain its blue colour, copper is present. See SALT.

NICOTIN. A peculiar principle obtained by Vauquelin from tobacco. It is colourless, and has the peculiar taste and smell of the plant. It dissolves both in water and alcohol; is volatile, poisonous, and precipitable from its solutions by tincture of galls.—*Ann. de Chimie*, tom. lxxi.

NIGRINE. An ore of titanium.

NIHIL ALBUM. A name formerly given to the flowers or white oxide of zinc.

NITRATES. Compounds of nitric acid with the salifiable bases.

NITRE. The common name of the nitrate of potash. See ACID (NITRIC).

NITROGEN, or AZOTE, an important elementary or undecomposed principle. As it constitutes four-fifths of the volume of atmospheric air, the readiest mode of procuring azote is to abstract its oxygenous associate, by the combustion of phosphorus or hydrogen. It may also be obtained from animal matters, subjected in a glass retort to the action of nitric acid, diluted with 8 or 10 times its weight of water.

Azote possesses all the physical properties of air. It extinguishes flame and animal life. It is absorbable by about 100 volumes of water. Its specific gravity is 0.9722. 100 cubic inches weigh 29.65 grains. It has neither taste nor smell.

Quantities of azote inappreciably minute by other tests may be detected in the following way.

Put a small piece of clean zinc foil into a glass tube sealed at one end, and about one-fourth of an inch in diameter; drop a piece of potash into the tube over the zinc; introduce a slip of turmeric paper slightly moistened at the extremity with pure water, retaining it in the tube in such a position that the wetted portion may be about two inches from the potash; then, holding the tube in an inclined position, apply the flame of a spirit lamp, so as to melt the potash that it may run down upon the zinc, and heat the two whilst in contact, taking care not to cause such ebullition as to drive up the potash. In a second or two the turmeric paper will be reddened at the moistened extremity, provided that part of the tube has not been heated. On removing the turmeric paper and laying the reddened portion upon the hot part of the tube, the original

Science, xix. 17.

If sea-sand after ignition be handled, it will acquire an azotic impregnation from the skin, sufficient to yield ammonia by turmeric paper when heated in a glass tube; which the sand itself would not do.—*Ibid.*

It unites with oxygen in four proportions, forming four important compounds. These are,

1. Protoxide of azote, or nitrous oxide.
2. Deutoxide of azote, nitrous gas, or nitric oxide.
3. Nitrous acid.
4. Nitric acid.

1. *Nitrous oxide* or *protoxide of azote*, was discovered by Dr. Priestley in 1772, but was first accurately investigated by Sir H. Davy in 1799. The best mode of procuring it, is to expose the salt called nitrate of ammonia, to the flame of an Argand lamp, in a glass retort. When the temperature reaches 400° F. a whitish cloud will begin to project itself into the neck of the retort, accompanied by the copious evolution of gas, which must be collected over mercury for accurate researches, but for common experiments may be received over water. It has all the physical properties of air. It has a sweet taste, a faint agreeable odour, and is condensable by about its own volume of water, previously deprived of its atmospheric air. This property enables us to determine the purity of nitrous oxide. A taper plunged into this gas burns with great brilliancy; the flame being surrounded with a bluish halo. But phosphorus may be melted and sublimed in it, without taking fire. When this combustible is introduced into it, in a state of vivid combustion, the brilliancy of the flame is greatly increased. Sulphur and most other combustible bodies require a higher degree of heat for their combustion in it, than in either oxygen or common air. This may be attributed to the counteracting affinity of the intimately combined azote. Its sp. grav. is 1.5277. 100 cubic inches weigh 46.6 gr. It is respirable, but not fitted to support life. Sir H. Davy first showed, that by breathing a few quarts of it, contained in a silk bag, for two or three minutes, effects analogous to those occasioned by drinking fermented liquors were produced. Individuals, who differ in temperament, are, however, as we might expect, differently affected.

Sir H. Davy describes the effect it had upon him as follows:—" Having previously closed my nostrils, and exhausted my lungs, I breathed four quarts of nitrous oxide from and into a silk bag. The first feelings were similar to those produced in the last experiment, (giddiness); but in less than half a minute the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by an highly pleasurable thrilling, particularly in the chest and the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspiration the thrilling increased, the sense of muscular power became greater, and at last an irresistible propensity to action was indulged in. I recollect but indistinctly what followed: I know that my motions were various and violent.

"These effects very soon ceased after respiration. In ten minutes I had recovered my natural state of mind. The thrilling in the extremities continued longer than the other sensations.

"The gas has been breathed by a very great number of persons, and almost every one has observed the same things. On some few, indeed, it has no effect whatever, and on others the effects are always painful.

"Mr. J. W. Tobin (after the first imperfect trials), when the air was pure, experienced sometimes sublime emotions with tranquil gestures, sometimes violent muscular action, with sensations indescribably exquisite; no subsequent debility—no exhaustion; his trials have been very numerous. Of late he has only felt sedate pleasure. In Sir H. Davy the effect is not diminished.

"Mr. James Thomson. Involuntary laughter, thrilling in his toes and fingers, exquisite sensations of pleasure. A pain in the back and knees, occasioned by fatigue the day before, recurred a few minutes afterwards. A similar observation, we think, we have made on others; and we impute it to the undoubted power of the gas to increase the sensibility or nervous power, beyond any other agent, and probably in a peculiar manner.

"Mr. Thomas Pople. At first unpleasant feelings of tension; afterwards agreeable luxurious languor, with suspension of muscular power; lastly, powers increased both of body and mind.

"Mr. Stephen Hammick, surgeon of the Royal Hospital, Plymouth. In a small dose, yawning and languor. It should be observed that the first sensation has often been disagreeable, as giddiness; and a few persons, previously apprehensive, have left off inhaling as soon as they felt this. Two larger doses produced a glow, unrestrainable tendency to muscular action, high spirits, and more vivid ideas. A bag of common air was first given to Mr. Hammick, and he observed that it produced no effect. The same precaution against the delusions of imagination was of course frequently taken.

"Mr. Robert Southey could not distinguish between the first effects and an apprehension of which he was unable to divest himself. His first definite sensations were, a fulness and dizziness in the head, such as to induce a fear of falling. This was succeeded by a laugh which was involuntary, but highly pleasurable, accompanied with a peculiar thrilling in the extremities; a sensation perfectly new and delightful. For many hours after this experiment, he imagined that his taste and smell were more acute, and is certain that he felt unusually strong and cheerful. In a second experiment he felt pleasure still superior, and has since poetically remarked, that he supposes the atmosphere of the highest of all possible heavens to be composed of this gas.

"Robert Kinglake, M. D. Additional freedom and power of respiration, succeeded by an almost delirious, but highly pleasurable sensation in the head, which became universal with increased tone of the muscles. At last, an intoxicating placidity absorbed for five minutes all voluntary power, and left a cheerfulness and alacrity for several hours. A second stronger dose produced a perfect trance for about a minute; then a glow pervaded the system. The permanent effects were an invigorated feeling of vital power, and improved spirits. By both trials, particularly by the former, old rheumatic feelings seemed to be revived for the moment.

"Mr. Wedgewood breathed atmospheric air first, without knowing it was so. He declared it to have no effect, which confirmed him in his disbelief of the power of the gas. After breathing this some time, however, he threw the bag from him, kept breathing on laboriously with an open mouth, holding his nose with his left hand, without power to take it away, though aware of the ludicrousness of his situation: all his muscles seemed to be thrown into vibrating motions; he had a violent inclination to make antic gestures, seemed lighter than the atmosphere, and as if about to mount. Before the experiment, he was a good deal fatigued after a long ride, of which he permanently lost all sense. In a second experiment, nearly the same effect, but with less pleasure. In a third, much greater pleasure."—*Res. on Nit. Ox.*

I have often verified these pleasurable effects, on myself and my pupils. The causes of failure, in most cases, I believe to be impure gas, a narrow tube or stop-cock, or precipitate breathing, from fear. If a little sulphate or muriate be mixed with the nitrate of ammonia, it will not yield an intoxicating gas. I use a pretty wide glass tube, fixed to the mouth of a large bladder.

I find that mice, introduced into a jar containing nitrous oxide, die almost instantly; while in azote, hydrogen, and carbonic acid, they struggle for a little while.

This gaseous compound may be analyzed by the combustion of hydrogen, carbon, or phosphorus in it. If we mix 100 volumes of nitrous oxide with 100 of hydrogen; and detonate the mixture in an explosive eudiometer, nothing will remain but 100 measures of azote. Hence 50 measures of oxygen, the equivalent quantity of 100 of hydrogen, must have existed in the oxide. It therefore consists of 100 measures of azote + 50 of oxygen, condensed by reciprocal attraction into only 100 measures.

Now 100 vol. of azote weigh 0.9722
50 of oxygen, $\frac{111.11}{2} = 0.5555$

1.5277

This synthetic sum exactly coincides with the specific gravity of the compound. It is therefore composed by weight of one prime

equivalent of azote,	= 1.75	63.64
one of oxygen,	= 1.00	36.36
	2.75	100.00

The weight of the compound prime is the same with that of carbonic acid.

Iron wire burns with brilliancy in the above gas, but it is soon extinguished.

2. *Deutoxide of azote*, or *nitric oxide*, was first described by Dr. Priestley in 1772. Into a glass retort, containing copper turnings, pour nitric acid diluted with six or eight times its quantity of water, and apply a gentle heat. A gas comes over, which may be collected over water; but for exact experiments, it should be received over mercury. Its sp. gr. is 1·0416. 100 cubic inches weigh 36·77 grains. Water condenses only about $\frac{1}{20}$ of its volume of nitric oxide. But a solution of protosulphate or protomuriate of iron absorbs it very copiously, forming a dark coloured liquid, which is used for condensing oxygen, in the eudiometer of Sir H. Davy.

When a jar of nitric oxide is opened in the atmosphere, red fumes appear in consequence of the absorption of oxygen, and formation of nitrous acid. When an animal is made to inhale this gas, it is instantly destroyed by the formation of this acid, and condensation of the oxygen in its lungs. When a burning taper is immersed in this gas, it is extinguished; as well as the flame of sulphur. But inflamed phosphorus burns in it with great splendour. A mixture of hydrogen gas and nitric oxide burns with a lambent green flame, but does not explode by the electric spark; though Fourcroy says that it detonates on being passed through an ignited porcelain tube. The pyrophorus of Homberg spontaneously burns in it.

It is decomposable by several of the metals, when they are heated in it, such as arsenic, zinc, and potassium in excess. It oxidizes them, and affords half its volume of azote. Charcoal ignited in it by a burning glass produces half a volume of azote, and half a volume of carbonic acid. All these analytical experiments concur to show, that nitric oxide consists of oxygen and azote, in equal volumes. Hence, if we take the mean weight of a volume of each gas, we shall have that of the gaseous compound; or, its sp. gr.

		Sum.	Hf. sum, or sp. gr.
Azote,	0·9722	2·0833	1·0416
Oxygen,	1·1111		

If we convert these into equivalent ratios, we shall have the gas composed of

1 prime of azote	= 1·75	46·68
2 primes oxygen	= 2·00	53·33
		100·00

When this deutoxide is exposed, at ordinary temperatures, to bodies which have a strong attraction for oxygen, such as the sulphites, protomuriate of tin, and the alkaline hydrosulphurets, two volumes of it are converted into one volume of the protoxide. We see here, that when one prime of oxygen is abstracted, the remaining one enters into a denser state of union with azote.

For the habitudes of this gas with hydrogen, see AMMONIA; and with oxygen, see EUDIOMETER, and NITRIC and NITROUS ACIDS.

Azote combines with chlorine and iodine to form two very formidable compounds:—

1. The chloride of azote was discovered about the beginning of 1812, by M. Dulong; but its nature was first investigated and ascertained by Sir H. Davy.

Put into an evaporating porcelain basin a solution of one part of nitrate or muriate of ammonia in 10 of water, heated to about 100°, and invert into it a wide-mouthed bottle filled with chlorine. As the liquid ascends by the condensation of the gas, oily-looking drops are seen floating on its surface, which collect together, and fall to the bottom in large globules. This is *chloride of azote*. By putting a thin stratum of common salt into the bottom of the basin, we prevent the decomposition of the chloride of azote, by the ammoniacal salt. It should be formed only in very small quantities. The *chloride of azote* thus obtained is an oily-looking liquid; of a yellow colour; and a very pungent intolerable odour, similar to that of chlorocarbonous acid. Its sp. gr. is 1·653. When tepid water is poured into a glass containing it, it expands into a volume of elastic fluid, of an orange colour, which diminishes as it passes through the water.

"I attempted," says Sir H. Davy, "to collect the products of the explosion of the new substance, by applying the heat of a spirit-lamp to a globule of it, confined in a curved glass tube over water: a little gas was at first extricated; but long before the water had attained the temperature of ebullition, a violent flash of light was perceived, with a sharp report; the tube and glass were broken into small fragments, and I received a severe wound in the transparent *cornea* of the eye, which has produced a considerable inflammation of the eye, and obliges me to make this communication by an amanuensis. This experiment proves what *extreme* caution is necessary in operating on this substance, for the quantity I used was scarcely as large as a grain of mustard-seed."—Phil. Trans. 1813, part I. It evaporates pretty rapidly in the air; and *in vacuo* it expands into a vapour, which still possesses the power of exploding by heat. When it is cooled artificially in water, or the ammoniacal solution, to 40° F., the surrounding fluid congeals; but when alone, it may be surrounded with a mixture of ice and muriate of lime, without freezing.

It gradually disappears in water, producing azote; while the water becomes acid, acquiring the taste and smell of a weak solution of nitro-muriatic acid.

With muriatic and nitric acids, it yields azote; and with dilute sulphuric acid, a mixture of azote and oxygen. In strong solutions of ammonia it detonates; with weak ones, it affords azote.

When it was exposed to pure mercury, out of the contact of water, a white powder (calomel) and azote were the results. "The action of mercury on the compound," says Sir H. "appeared to offer a more correct and less dangerous mode of attempting its analysis; but on introducing two grains under a glass tube filled with mercury, and inverted, a violent detonation occurred, by which I was slightly wounded in the head and hands, and should have been severely wounded, had not my eyes and face been defended by a plate of glass, attached to a proper cap; a precaution very necessary in all investigations of this body."—Phil. Trans. 1813, part II. In using smaller quantities, and recently distilled mercury, he obtained the results of the experiments, without any violence of action.

From his admirable experiments on the analysis of this formidable substance, by mercury, by muriatic acid, and from the discoloration of sulphate of indigo, we may infer its composition to be

4 vol. of chlorine = 10 4 primes 18·0
1 of azote = 0.9722 1 1·75

or very nearly 10 by weight of chlorine to 1 of azote.

A small globule of it thrown into a glass of olive oil, produced a most violent explosion; and the glass, though strong, was broken into fragments. Similar effects were produced by its action on oil of turpentine and naphtha. When it was thrown into ether or alcohol, there was a very slight action. When a particle of it was touched under water by a particle of phosphorus, a brilliant light was perceived under the water, and permanent gas was disengaged, having the characters of azote.

When quantities larger than a grain of mustard-seed were used for the contact with phosphorus, the explosion was always so violent as to break the vessel in which the experiment was made. On tinfoil and zinc it exerted no action; nor on sulphur and resin. But it detonated most violently when thrown into a solution of phosphorus in ether or alcohol.

The mechanical force of this compound in detonation, seems superior to that of any other known, not even excepting the ammoniacal fulminating silver. The velocity of its action appears to be likewise greater. I touched a minute globule of it, in a platina spoon resting on a table, with a fragment of phosphorus at the point of a penknife. The blade was instantly shivered into fragments by the explosion.

Messrs. Porrett, Wilson, and Rupert Kirk, brought 125 different substances in contact with it. The following were the only ones which caused it to explode:—

Supersulphuretted hydrogen.
Phosphorus.
Phosphuret of lime
Phosphuretted camphor.
Camphoretted oil.
Phosphuretted hydrogen gas.
Caoutchouc.
Myrrh.
Palm oil.
Ambergris.
Whale oil.
Linseed oil.
Olive oil.
Sulphuretted oil.
Oil of turpentine.
——— tar.
——— amber.
——— petroleum.
——— orange peel.
Naphtha.
Soap of silver.
——— mercury.
——— copper.
——— lead.
——— manganese.
Fused potash.
Aqueous ammonia.
Nitrous gas.—*Nich. Journ.* vol. 34.

2. *Iodide of azote.* Azote does not combine directly with iodine. We obtain the combination only by means of ammonia. It was discovered by M. Courtois, and carefully examined by M. Colin. When ammoniacal gas is passed over iodine, a viscid shining liquid is immediately formed of a brownish-black colour, which, in proportion as it is saturated with ammonia, loses its lustre and viscosity. No gas is disengaged during the formation of this liquid, which may be called *iodide of ammonia.* It is not fulminating. When dissolved in water, a part of the ammonia is decomposed; its hydrogen forms hydriodic acid; and its azote combines with a portion of the iodine, and forms the fulminating powder. We may obtain the iodide of azote directly, by putting pulverulent iodine into common water of ammonia. This indeed is the best

The iodide of azote is pulverulent, and of a brownish-black colour. It detonates from the smallest shock, and from heat, with a feeble violet vapour. When properly prepared, it often detonates spontaneously. Hence, after the black powder is formed, and the liquid ammonia decanted off, we must leave the capsule containing it in perfect repose.

When this iodide is put into potash water, azote is disengaged, and the same products are obtained as when iodine is dissolved in that alkaline lixivium. The hydriodate of ammonia, which has the property of dissolving a great deal of iodine, gradually decomposes the fulminating powder, while azote is set at liberty. Water itself has this property, though in a much lower degree. As the elements of iodide of azote are so feebly united, it ought to be prepared with great precautions, and should not be preserved. In the act of transferring a little of it from a platina capsule to a piece of paper, the whole exploded in my hands, though the friction of the particles on each other was inappreciably small.

Both Sir H. Davy and M. Gay Lussac have exploded their iodide in glass tubes, and collected the results. The latter states, "that if we decompose a gramme (15·444 grains) of the fulminating powder, we obtain, at the temperature of 32°, and under the pressure of 30 inches of mercury, a gaseous mixture amounting to 0·1152 litre, (7·03 cubic inches), and composed of 0·0864 of the vapour of iodine, and 0·0288 of azote."—*Ann. de Chim.* xci. Now 0·0864 is to 0.0288 as 3 to 1 exactly. Therefore the detonating powder consists of

3 vols. of the va. of iod. = 8·63 × 3 = 25·89
1 vol. of azote = = 0·9722

or reduced to the oxygen equivalent scale, it consists of

3 primes of iodine	=	46·5	96·37
1 azote	=	1·75	3.63
			100·00

Azote has hitherto resisted all attempts to decompose it. Sir H. Davy volatilized the highly combustible metal potassium in azote over mercury, and passed the voltaic flame of 2000 double plates through the vapour; but the azote underwent no change. He made ammonia were ignited together in a Reaumur porcelain tube, connected with water in a Woolfe's apparatus, a portion of ammonia constantly disappeared, or was annihilated, while nothing but water was obtained to replace that loss. "Of the tightness of the apparatus I am well assured. Indeed, I have performed the experiment with a continuous glass tube, sealed and bent down at one end like a retort, while the other end was drawn into a small tube, which passed under a jar on the mercurial pneumatic shelf. The middle part was kept horizontal, and artificially cooled. The sealed end contained the mixture of lime and sal ammoniac. A brush flame of a large alcohol blowpipe was made to play very gently on the end of the tube at first, but afterwards so powerfully, as to keep it ignited for some time. The sal ammoniac recovered did not exceed three-fourths of that originally employed." The sal ammoniac was regenerated by saturating the ammonia with muriatic acid, and cautious evaporation. *See Ann. of Phil. September*, 1817.

The strongest arguments for the compound nature of azote are derived from its slight tendency to combination, and from its being found abundantly in the organs of animals which feed on substances that do not contain it.

Its uses in the economy of the globe are little understood. This is likewise favourable to the idea that its real chemical nature is as yet unknown, and leads to the hope of its being decomposable.

It would appear that the atmospheric azote and oxygen spontaneously combine in other proportions, under certain circumstances, in natural operations. Thus we find, that mild calcareous or alkaline matter favours the formation of nitric acid in certain regions of the earth; and that they are essential to its production in our artificial arrangements for forming nitre from decomposing animal and vegetable substances.

NITROUS ACID. See ACID (NITROUS).

NOBLE METALS. This absurd name has been bestowed on the perfect metals, gold, silver, and platina.

NUCLEUS OF CRYSTALS. See CRYSTALLIZATION.

NOVACULITE. WHETSLATE.

NUX VOMICA. See STRYCHNIA.

OBSIDIAN. Of this mineral there are two kinds, the translucent and transparent.

1. *Translucent obsidian.* Colour velvet-black. Massive. Specular splendent. Fracture perfect conchoidal. Translucent, or translucent on the edges. Hard. Very brittle. Easily frangible. Streak gray. Sp. gr. 2·37. It melts, or becomes spongy before the blowpipe. Its constituents are, silica 78, alumina 10, lime 1, soda 1.6, potash 6, oxide of iron 1. —*Vauq.* It occurs in beds in porphyry, and various secondary trap rocks in Iceland and Tokay.

2. *Transparent.* Colour duck blue. Massive and in brown grains. Splendent. Fracture perfect conchoidal. Perfectly transparent. Hard. Brittle. Sp. gr. 2·36. It melts more easily than the translucent obsidian, and into a white muddy glass. Its constituents are, silica 81, alumina 9·5, lime 0.33, oxide of iron 0·60, potash 2.7, soda 4.5, water 0.5.—*Klaproth.* It occurs imbedded in pearl-stone porphyry. It is found at Marekan, near Ochotsk in Siberia, and in the Serro de las Novajas in Mexico.

OCHRE. An ore of iron.

OCHROITS. Cerite.

OCTOHEDRITE. Pyramidal titanium ore.

ODOUR. The emanation of an odoriferous body is generally ascribed to a portion of the body itself, converted into vapour. M. Robiquet, from a series of experiments published in the *Annales de Chimie et de Physique*, xv. 27. thinks, that in many cases the odour is owing, not to the substance itself, but to a gas or vapour resulting from its combination with an appropriate vehicle, capable of diffusion in space.

OETITES. Clay ironstone.

OIL OF VITRIOL. See Acid (Sulphuric).

OIL. The distinctive characters of oil are inflammability, insolubility in water, and fluidity, at least in a moderate temperature. Oils are distinguished into fixed or fat oils, which do not rise in distillation at the temperature of boiling water; and volatile or essential oils, which do rise at that temperature with water, or under 320° by themselves.

The volatile oil obtained by attenuating animal oil, by a number of successive distillations, is called Dippel's animal oil.

Monnet asserts, that, by mixing acids with animal oil, their rectification may be very much facilitated.

The addition of a little ether, before redistillation of old essential oils, improves the flavour of the product. See Elain and Acid (Oleic).

Fixed oils differ greatly in their gravities, as appears from the following

Cacoa,	0·892
Rape-seed,	0·913
Olives,	0·913
Ben,	0·917
Beech-nut,	0·923
Walnuts,	0·923 to 0·947
Almonds,	0·932
Linseed,	0·939
Poppies,	0·939
Hazel-nuts,	0·941
Oil of palm,	0·968

MM. Gay Lussac and Thenard an olive oil in 1808, by igniting a detern quantity of it, mixed with chlorate of p and ascertaining the products: they fo to consist of

	Carbon,	77·213
	Hydrogen,	13·360
	Oxygen,	9·427
		100·000
Or,	Carbon,	77·213
Ox. and hydr. in the proportions for forming water,		10·712
	Hydrogen excess,	12·075

Spermaceti oil by my analysis consis 100 parts of carbon 78·91, hydrogen 1(oxygen 10·12, or

Carbon,	10 atoms	7·5	78·0
Hydrogen,	8 do.	1·	11·5
Oxygen,	1 do.	1·000	10·5
			100·0

In other terms 9 atoms olefiant gas, 1 carb oxide, and 1 carbon.

Oil of turpentine gave me in analysis, car 82·51, hydrogen 9·62, oxygen 7·87;

Or Carbon,	14 atoms	10·5	82·3
Hydrogen,	10 do.	1.25	9·8
Oxygen,	1 do.	1·00	7·6

Phil. Trans. 1822

Vauquelin has shown that volatile oils, oil of lavender, absorb pure acetic acid in v large quantities, the greater part of which tl give up to water by agitation with it. Oil turpentine combines largely with alcoh forming a homogeneous body. This eff is produced by a solution of the alcohol in t oil; for 1 part of alcohol cannot be suppos to dissolve 5 of oil. When that compound long and repeatedly agitated with water, t whole alcohol cannot be separated; about of the volume remaining combined, witho our being able to perceive it, if it be not l the specific gravity which is a little diminishe

By repeated lotions with much water the alcohol may be all finally removed. *Ann. de Chim.* xix. 279.

If the pernitrate of mercury, made by dissolving 6 parts of mercury in 7·5 parts of nitric acid, of sp. gr. 1·36 at common temperatures, be mixed with olive oil, in the course of a few hours the mixture, if kept cold, becomes solid; but if mixed with the oil of grains, it does not solidify. M. Pontet proposes therefore this substance as a test of the purity or adulteration of olive oil; for the resulting mixture, after standing 12 hours, is more or less solid, as the oil is more or less pure. The nature of the white, hard, and opaque mixture, formed by olive oil and the nitrate of mercury, has not been ascertained. See ACID (MARGARIC), ELAIN, and FAT.

OIL OF AMBER. When amber is distilled in a retort, it yields about one-third its weight of a fetid brown oil, which is occasionally used as an antispasmodic in medicine.

OIL GAS. It has been long known to chemists, that wax, oil, tallow, &c. when passed through ignited tubes, are resolved into combustible gaseous matter, which burns with a rich light. Messrs. Taylor and Martineau have availed themselves skilfully of this fact, and contrived an ingenious apparatus for generating oil gas on the great scale, as a substitute for candles, lamps, and coal gas. I shall insert, here, a brief account of their improvements.

The advantages of oil gas, when contrasted with coal gas, are the following:—The material from which it is produced containing no sulphur or other matter by which the gas is contaminated, there are no objections to its use on account of the suffocating smell in close rooms. It does no sort of injury to furniture, books, plate, pictures, paint, &c. All the costly and offensive operation of purifying the gas by lime, &c. is totally avoided when it is obtained from oil. Nothing is contained in oil gas which can possibly injure the metal of which the conveyance pipes are made.

The economy of light from oil gas may be judged from the following table:—

Argand burner oil gas, per hour, .	¾*d.*
Argand lamps spermaceti oil, .	3*d.*
Mould candles, ...	3½*d.*
Wax candles, ...	14*d.*

The oil gas has a material advantage over coal gas, from its peculiar richness in olefiant gas, which renders so small a volume necessary, that one cube foot of oil gas will be found to go as far as four of coal gas. This circumstance is of great importance, as it reduces in the same proportion the size of the gasometers which are necessary to contain it: this is not only a great saving of expense in the construction, but is a material convenience where room is limited.

In the course of their first experiments, Messrs. John and Philip Taylor were surprised to find, that the apparatus they employed gradually lost its power of decomposing oil, and generating gas. On investigation they discovered, that the metallic retorts which had originally decomposed oil and produced gas in abundance, ceased in a very great degree to possess this power, although no visible change had taken place in them.

The most perfect cleaning of the interior of the retort did not restore the effect, and some alteration appears to be produced on the iron by the action of the oil, at a high temperature.

Fortunately the experiments on this subject led to a most favourable result, for it was found, that by introducing fragments of brick into the retorts, a great increase of the decomposing power was obtained, and the apparatus has been much improved by a circumstance which at one time appeared to threaten its success.

A small portion of the oil introduced into the retort still passed off undecomposed, and being changed into a volatile oil, it carried with it a great portion of caloric, which rendered the construction of the apparatus more difficult than was at first anticipated; but by the present arrangement of its parts, this difficulty is fully provided for, and the volatilized oil is made to return into the oil reservoir, from whence it again passes into the retort, so that a total conversion of the whole into gas is accomplished without trouble, or the escape of any unpleasant smell.

A general idea of the process may be formed from the following account of it:—

A quantity of oil is placed in an air-tight vessel, in such a manner that it may flow into retorts which are kept at a moderate red heat; and in such proportions as may regulate the production of gas to a convenient rate; and it is provided, that this rate may be easily governed at the will of the operator.

The oil, in its passage through the retorts, is principally decomposed, and converted into gas proper for illumination, having the great advantages of being pure and free from sulphurous contamination, and of supporting a very brilliant flame, with the expenditure of very small quantities.

As a further precaution to purify the gas from oil, which may be suspended in it in the state of vapour, it is conveyed into a wash vessel, where, by bubbling through water, it is further cooled and rendered fit for use; and passes by a proper pipe into a gasometer, from which it is suffered to branch off in pipes in the usual manner.

The oil gas which I have been accustomed to make has only a double illuminating power, compared to good coal gas.—See a drawing of an elegant apparatus, erected by Messrs. P. and M. at the Apothecaries' Hall, London, in the 15th Number of the Journal of Science and the Arts.

When the gaseous matter obtained by the igneous decomposition of oil is compressed to about one-thirtieth of its volume, as by the portable gas company, a certain new liquid compound results. This fluid is colourless or opalescent, yellow by transmitted, green by reflected light, of a specific gravity less than water, insoluble in water unless in very minute quantities, soluble in alcohol, ether, oils, &c., and combustible, burning with a dense flame. It is well distinguished from the oil that afforded it, by being very slightly acted upon by alkaline solutions. When the bottle containing it is opened, evaporation takes place from the surface of the liquid, as is obvious from the *striæ* in the air. This vapour soon ceases, and the remainder is comparatively fixed. It has the smell of oil gas.

Its specific gravity is 0·821. It does not solidify at 0° F. It is neutral to test colours. Muriatic acid has no action on it. Sulphuric acid acts on it, in a peculiar manner.

This fluid is a mixture of various bodies, which may, by their difference of volatility, be separated in some degree from each other. When the vessel containing it is opened, it begins to boil at 60° F. As the more volatile portions are dissipated, the temperature rises; and before a tenth part is thrown off, the temperature exceeds 100°. The heat after this continues to rise, and before the substance is all dissipated, it becomes 250°.

A liquid distilled over, when the retort was at 176°, became partly solid in the receiver, crystals forming round the side, and a fluid remaining in the centre; while two other portions, one drawn off at 186° F., another at 190°, became quite hard at 0° F. This being dried by bibulous paper, introduced into it by a glass rod, did not become fluid until raised to 28° or 29° F. After being squeezed in a Bramah's press between folds of blotting paper, contained between plates cooled to 0°, it was ultimately distilled off caustic lime, to separate any water it might still contain. This substance is a bicarburet of hydrogen. It is, at ordinary temperatures, a transparent colourless liquid, having somewhat of the odour of almonds, and a specific gravity of 0·85 at 60°. It crystallizes at 32°. Its fusing point is more exactly 42°. It contracts very much on congealing, 9 parts in bulk becoming very nearly 8, when its density becomes 0.956. At 0°, it appears as a white or transparent substance, brittle, pulverulent, and of the hardness nearly of loaf sugar. It evaporates entirely when exposed to the air. Its boiling point is 186° in a glass vessel. The sp. gr. of its vapour, equated to a temperature of 60°, is nearly 40 times that of hydrogen. It does not conduct electricity. When admitted to oxygen gas, so much vapour rises, as to constitute a powerfully detonating mixture. By transmission through an ignited tube, it becomes carburetted hydrogen, with deposition of charcoal. Chlorine, aided by the sunbeam, combines with it, and triple compounds of chlorine, carbon, and hydrogen, result. Potassium is not affected by it, even at 186° F. Its constituents are, carbon 1·5 + hydrogen 0·125.

Another product from the distillation of the condensed oil-gas liquid, is that which is most volatile. It forms a liquid at 0°, but is all resolved into gas at 32° F. This gas is very combustible. It is 28 times denser than hydrogen. Its density, in the liquid state, is 0·627 at 54°; taken by weighing some of it in a glass tube, hermetically sealed. *It is, therefore, the lightest of solids or liquids.* One volume of the vapour consists of four volumes of hydrogen, combined with four of vapour of carbon; which, on the hydrogen *radix*, gives for its density $(4 \times 1) + (4 \times 6) = 28$. It is therefore the same as olefiant gas condensed into half its usual volume. The oil gas liquid is an excellent solvent of caoutchouc, surpassing every other substance in this quality. —*Faraday.*

OIL OF WINE. This liquid is produced at a certain period, during the distillation of a mixture of sulphuric acid and alcohol, in the formation of ether. It is a perfectly neutral substance. When heated, it evolves combustible matter, and becomes highly acid; the combustible matter is hydro-carbon. Upon examining the acid thus produced, it is found to be the same with the *sulphovinic* acid, and united with bases it forms sulphovinates. Oil of wine consists of 2 atoms of sulphuric acid, 8 of carbon, and 8 of hydrogen. It is neutral; but, by heat, gives off half of the carbon and hydrogen, while sulphovinic acid remains, composed of 2 atoms of sulphuric acid, 4 of carbon, and 4 of hydrogen; which elements, with an atom of any base, form sulphovinates.

When oil of wine is mixed with a cold solution of muriate of barytes, no change takes place; but if heat be applied to the mixture, sulphate of barytes precipitates. 38 per cent. of sulphuric acid is thus indicated in oil of wine; the remaining 62 parts are carbon and hydrogen, in the same proportions as they exist in olefiant gas.—*Hennel. Phil. Trans.*, 1826. *Part 3d.*

OISANITE. Pyramidal titanium-ore.

OLEFIANT GAS. A compound of one prime of carbon and one of hydrogen, to which I have given the name of CARBURETTED HYDROGEN, to distinguish it from the gas resulting from one prime of carbon and two of hydrogen, which I have called subcarburetted hydrogen.

OLEIC ACID. See ACID (OLEIC).

OLEOSACCHARUM. This name is given to a mixture of oil and sugar incorporated with each other, to render the oil more easily diffusible in watery liquors.

OLEUM VINI. See ETHER.

or tears. The best is of a yellowish-white colour, solid, hard, and brittle: when chewed for a little time, it renders the spittle white, and impresses an unpleasant bitterish taste; laid on burning coals, it yields an agreeable smell.

OLIVENITE. An ore of copper.

OLIVINE. A sub-species of prismatic chrysolite. Its colour is olive-green. It occurs massive and in roundish pieces. Rarely crystallized in imbedded rectangular four-sided prisms. Lustre shining. Cleavage imperfect double. Fracture small-grained uneven. Translucent. Less hard than chrysolite. Brittle. Spec. grav. 3.24. With borax it melts into a dark green bead. It loses its colouring iron in nitric acid. Its constituents are, silica 50, magnesia 38.5, lime 0.25, oxide of iron 12. It occurs in basalt, greenstone, porphyry, and lava, and generally accompanied with augite. It is found in the Lothians, Hebrides, north of Ireland, Iceland, France, Bohemia, &c.

OLLARIS LAPIS. See POTSTONE.

OMPHACITE. Colour pale leek-green. Massive, disseminated, and in narrow radiated concretions. Lustre glistening and resinous. Fracture fine-grained uneven. Feebly translucent. As hard as felspar. Sp. gr. 3.3. It occurs in primitive rocks, with precious garnet, in Carinthia. It is a variety of augite.

ONYX. Calcedony, in which there is an alternation of white, black, and dark-brown layers.

OPACITY. The faculty of obstructing the passage of light.

OPAL. A sub-species of the indivisible quartz of Mohs.

Of opal there are seven kinds, according to Professor Jameson.

1. *Precious opal.* Colour milk-white, inclining to blue. It exhibits a beautiful play of many colours. Massive, disseminated, in plates and veins. Lustre splendent. Fracture perfect conchoidal. Translucent, or semi-transparent. Semi-hard in a high degree. Brittle. Uncommonly easily frangible. Sp. gr. 2·1. Before the blowpipe it whitens and becomes opaque, but does not fuse. Its constituents are, silica 90, water 10. It occurs in small veins in clay porphyry, with semi-opal, at Czscherwenitza, in Upper Hungary; and in trap rocks at Sandy Brae, in the north of Ireland. Some of them become transparent by immersion in water; and are called oculus mundi, hydrophane, or changeable opal.

2. *Common opal.* Colour milk-white. Massive, disseminated, and in angular pieces. Lustre splendent. Fracture perfect conchoidal. Semitransparent. Scratches glass. Brittle. Adheres to the tongue. Infusible. Its constituents are, silica 93·5, oxide of iron 1, water

north of Ireland.

3. *Fire opal.* Colour hyacinth-red. Lustre splendent. In distinct concretions. Fracture perfect conchoidal. Completely transparent. Hard. Uncommonly easily frangible. Sp. gr. 2.12. Heat changes the colour to pale flesh-red. Its constituents are, silica 92, water 7·75, iron 0.25. It has been found only at Zimapan in Mexico, in a particular variety of hornstone porphyry.

4. *Mother-of-pearl opal*, or *Cacholong.* It is described under CACHOLONG, as a variety of calcedony.

5. *Semi-opal.* Colours white, gray, and brown; sometimes in spotted, striped, or clouded delineations. Massive, disseminated, and in imitative shapes. Lustre glistening. Fracture conchoidal. Translucent. Semi-hard. Rather easily frangible. Sp. gr. 2·0. Infusible. Its constituents are, silica 85, alumina 3, oxide of iron 1·75, carbon 5, ammoniacal water 8, bituminous oil 0·33.—*Klaproth.* It occurs in porphyry and amygdaloid, in Greenland, Iceland, and Scotland, in the Isle of Rume, &c.

6. *Jasper opal*, or *Ferruginous opal.* Colour scarlet-red, and gray. Massive. Lustre shining. Fracture perfect conchoidal. Opaque. Between hard and semi-hard. Easily frangible. Sp. gr. 2·0. Infusible. Its constituents are, silica 43·5, oxide of iron 47·0, water 7·5.—*Klaproth.* It is found in porphyry at Tokay in Hungary.

7. *Wood opal.* Colours very various. In branched pieces and stems. Lustre shining. Fracture conchoidal. Translucent. Semi-hard in a high degree. Easily frangible. Sp. gr. 2·1. It is found in alluvial land at Zastravia in Hungary.

OPIUM. See MORPHIA, and ACID (MECONIC). In the 8th and 9th volumes of the Journal of Science, and in the 1st of the Edinburgh Phil. Journal, are two valuable papers on the manufacture of British opium; the first by the Rev. G. Swayne, the second by Mr. Young. The manufacture of Indian opium has been of late years greatly improved by Dr. Fleming, M. P., under whose superintendence that important department was placed by the Marquis of Wellesley.

According to Orfila, a dangerous dose of opium is rather aggravated than counteracted by vinegar. The proper remedy is a powerful emetic, such as sulphate of zinc, or sulphate of copper. See an interesting and well treated case, in the 1st volume of the Medico-Chirurgical Trans. by Dr. Marcet and Mr. Astley Cooper.

The experiments of M. Magendie have shown that the salt extracted long ago from opium by Derosnes, and which has been called *narcotine*, produces a stupor differing from real sleep, and acts on dogs as a poison in small doses. This *narcotine* may be separated, by sulphuric ether, from the strained watery extract of opium. The ether afterwards deposits the *narcotine* in crystals; while the residuary opium is supposed to be better fitted than before, for procuring tranquil sleep.

OPOBALSAM. The most precious of the balsams is that commonly called Balm of Gilead, Opobalsamum, Balsamælon, Balsamum verum album, Ægyptiacum, Judaicum, Syriacum, è Mecca, &c. This is the produce of the amyris opobalsamum, L.

The true balsam is of a pale yellowish colour, clear and transparent, about the consistence of Venice turpentine, of a strong, penetrating, agreeable, aromatic smell, and a slightly bitterish pungent taste. By age it becomes yellower, browner, and thicker, losing by degrees, like volatile oils, some of its finer and more subtile parts. To spread, when dropped into water, all over the surface, and to form a fine, thin, rainbow-coloured cuticle, so tenacious that it may be taken up entire by the point of a needle, were formerly infallible criteria of the genuine opobalsam. Neumann, however, had observed, that other balsams, when of a certain degree of consistence, exhibit these phenomena equally with the Egyptian. According to Bruce, if dropped on a woollen cloth, in its pure and fresh state, it may be washed out completely and readily with simple water.

OPODELDOC. A solution of soap in alcohol, with the addition of camphor and volatile oils. It is used externally against rheumatic pains, sprains, bruises, and other like complaints.

OPOPANAX. A concrete gummy resinous juice, obtained from the roots of an umbelliferous plant, the pastinaca opopanax, *Linn.*, which grows spontaneously in the warmer countries, and bears the colds of this. The juice is brought from Turkey and the East Indies, sometimes in round drops or tears, but more commonly in irregular lumps, of a reddish-yellow colour on the outside, with specks of white; inwardly of a paler colour, and frequently variegated with large white pieces. It has a peculiar strong smell, and a bitter, acrid, somewhat nauseous taste.

ORES. The mineral bodies from which metals are extracted.

I. ANTIMONY, *Ores of.*

I. *Native antimony*, of which there are two species; dodecahedral, and octohedral.

1. *Dodecahedral.* Colour tin-white. Massive and crystallized in an octohedron and dodecahedron. Harder than calcareous spar. Sp. gr. 6.7. It consists of 98 antimony, 1.0 silver, and 0.25 iron. It is found in argentiferous veins in the gneiss mountains of Chalanches in Dauphiny, and at Andreasberg in the Hartz.

2. *Octohedral antimony;* of which there are two sub-species, the antimonial silver, and arsenical silver. See ORES OF SILVER.

II. ANTIMONY GLANCE. Under this genus are ranged the following species, subspecies, and kinds.

1. *Compact gray antimony.* Colour light lead-gray. Massive. Soft. Easily frangible. Sp. gr. 4.4. Found in Huel Boys mine in Cornwall.

2. *Foliated gray antimony.* Colour like the preceding. Cleavage prismatic. Not particularly brittle. Sp. gr. 4.4.

3. *Radiated gray antimony.* Colour common lead-gray. Massive, and crystallized in four and six-sided prisms, and sometimes in acicular crystals. Lustre metallic. Sp. gr. 4.4. It melts by the flame of a candle. Its constituents are, antimony 75, sulphur 25. These minerals occur in veins, in primitive and transition mountains. This occurs in Glendinning in Dumfriesshire, in Cornwall, &c.

4. *Plumose gray antimony.* Colour between dark lead-gray and smoke-gray. Massive, and in capillary glistening crystals. Lustre semi-metallic. Very soft. It melts into a black slag. It contains antimony, sulphur, arsenic, iron, and silver. It occurs in veins in primitive rocks, at Andreasberg in the Hartz, &c.

5. *Axifrangible antimony glance* or *Bournonite.* Colour blackish lead-gray. Massive and crystallized. Primitive form, an oblique four-sided prism, which occurs variously modified by truncation, &c. Lustre metallic. Cleavage axifrangible. Fracture conchoidal. Brittle. Sp. gr. 5.7. Its constituents are, lead 42.62, antimony 24.23, copper 12.8, iron 1.2, sulphur 17.—*Hatchett.* It is found near Endellion in Cornwall.

6. *Prismatic antimony glance.* Colour blackish lead-gray. Primitive form, an oblique four-sided prism. Lustre metallic. Cleavage in the direction of the smaller diagonal of the prism. Sp. gr. 5.75.

III. *Antimony ochre.* Colour straw-yellow, incrusting crystals of gray antimony. Dull. Fracture earthy. Very soft. Brittle. Whitens and evaporates before the blowpipe. It occurs in veins in Saxony, &c.

IV. *Nickeliferous gray antimony.* Colour steel-gray. Massive. Shining. Cleavage double rectangular. Fragments cubical. Brittle. Sp. gr. 6 to 6.7. It melts before the blowpipe, emitting white vapour of arsenic. It communicates a green colour to nitric acid. It consists of antimony with arsenic 61.68, nickel 23.33, sulphur 14.16, silica, with silver and lead, 0.83, and a trace of iron. It occurs in veins near Fruesberg in Nassau.

V. *Prismatic white antimony.* Colour white. Massive and crystallized, in a rectangular four-sided prism, an oblique four-sided prism, a rectangular four-sided table, a six-sided prism, and in acicular and capillary crystals. Lustre pearly or adamantine. Cleavage in the direction of the lateral planes. Translucent. Sectile. Sp. gr. 5.0 to 5.6. It melts and volatilizes in a white vapour. Its constituents are, oxide of antimony 86, oxides of antimony and iron 3, silica 8. It occurs in veins in primitive rocks in Bohemia and Hungary.

VI. *Prismatic antimony-blende*, or *red antimony*.

a. Common. Colour cherry-red. Massive, in flakes, and crystallized. Primitive form, an oblique four-sided prism. Crystals delicate capillary. Adamantine. Translucent on the edges. Brittle. Sp. gr. 4.5 to 4.6. It melts and evaporates before the blowpipe. It consists of antimony 67.5, oxygen 10.8, sulphur 19.7.—*Klapr*. It occurs at Braunsdorf in Saxony.

b. Tinder antimony-blende. Colour muddy cherry-red. In flexible tinder-like leaves. Feebly glimmering. Opaque. Streak shining. Friable. Sectile and flexible. It contains oxide of antimony 33, oxide of iron 40, oxide of lead 16, sulphur 4, with some silver. —*Link*. It occurs in the Carolina and Dorothea mines at Clausthal.

II. ARSENIC.

1. *Native arsenic*. Fresh fracture, whitish lead-gray. Massive, and in imitative shapes. Feebly glimmering. Harder than calcareous spar. Streak shining, metallic. When struck, it has a ringing sound, and emits an arsenical odour. Sp. gr. 5.75. It occurs in veins in primitive rocks, at Kongsberg in Norway, &c.

2. *Oxide of arsenic*; common, capillary, and earthy.

a. Common oxide has a white colour; occurs in crystalline crusts; has a shining lustre; uneven fracture; and is soft and semitransparent.

b. The capillary occurs in silky, snow-white, shining, capillary crystals.

c. The earthy is yellowish-white; in crusts. Dull, opaque, and friable. It occurs at Andreasberg in the Hartz.

3. *Arsenical pyrites.*

a. Common arsenical pyrites. Mispickel. Fresh fracture silver-white. Massive and in prismatic concretions. Crystallized in oblique four-sided prisms. Lustre splendent metallic. Fracture coarse-grained. Cleavage in the direction of the perpendicular prism. Sometimes as hard as felspar. Brittle. It emits an arsenical smell on friction. Sp. gr. 5.7 to 6.2. Before the blowpipe it yields a copious arsenical vapour. Its constituents are, arsenic 43.4, iron 34.9, sulphur 20.1. It occurs in primitive rocks, in Cornwall and Devonshire, and at Alva in Stirlingshire.

b. Argentiferous arsenical pyrites. Colour silver-white. Disseminated, and in very small acicular, oblique, four-sided prisms. Shining and metallic. Besides arsenic and iron, it contains from 0.01 to 0.10 of silver. It has been found in Saxony; and is used as an ore of silver.

4. *Pharmacolite*, or *arsenic-bloom*. Colour reddish-white. As a coating of balls, or in delicate capillary shining silky crystals. Semi-transparent, or opaque. Soft. Soils. Sp. gr. 2.64. Its constituents are, lime 25, arsenic acid 50.44, water 24.56. It occurs in veins along with tin-white cobalt at Andreasberg, &c.

5. *Orpiment.*

a. Red; ruby sulphur, or *hemi-prismatic sulphur*. Colour aurora-red; massive; in flakes, and crystallized in oblique four-sided prisms. Lustre inclining to adamantine. Fracture uneven. Translucent. Streak orange-yellow coloured. As hard as talc. Brittle. Sp. gr. 3.35. It melts and burns with a blue flame. It is idio-electric by friction. Its constituents are, arsenic 69, sulphur 31. It occurs in primitive rocks at Andreasberg, &c.

b. Yellow orpiment, or *prismatoidal sulphur*. Colour perfect lemon-yellow. Massive, imitative, and crystallized in oblique four-sided prisms, and in flat double four-sided pyramids. Cleavage prismatoidal. Translucent. Harder than the red. Flexible, but not elastic. Splits easily. Sp. gr. 3.5. Its constituents are, arsenic 62, sulphur 38. It occurs in veins in floetz rocks; and along with red silver in granite at Wittichen in Swabia.

III. BISMUTH.

1. *Native* or *octohedral bismuth*. Fresh fracture silver-white, inclining to red. Massive and crystallized in an octohedron, tetrahedron, and cube. Lustre splendent, metallic. Cleavage fourfold. Harder than gypsum. Malleable. Sp. gr. 8.9 to 9.0. It melts by the flame of a candle. It occurs in veins in mica-slate, &c. at St. Columb and Botallack, in Cornwall; and in Saxony.

2. *Bismuth-glance*.

a. Acicular bismuth-glance. Colour dark lead-gray. Disseminated, and crystallized in oblique four or six-sided prisms. Lustre splendent, metallic. Fracture uneven. Opaque. Brittle. Sp. gr. 6.1 to 6.2. It fuses before the blowpipe into a steel-gray globule. Its constituents are, bismuth 43.2, lead 24.32, copper 12.1, sulphur 11.58, nickel 1.58, tellurium 1.32, gold 0.79. It occurs embedded in quartz near Beresof in Siberia. It is also called *needle ore*.

b. Prismatic bismuth glance. Colour pale lead-gray. Massive, and crystallized in acicular and capillary oblique four and six-sided prisms. Lustre splendent, metallic. It soils; is brittle; and harder than gypsum. Sp. gr. 6.1 to 6.4. It melts in the flame of a candle. Its constituents are, bismuth 60, sulphur 40. It occurs in veins in Cornwall, &c.

sulphur 12.58. It occurs in veins in granite near Wittichen in Furstemberg.

b. Bismuth ochre. Colour straw-yellow. Massive. Lustre inclines to adamantine. Opaque. Soft. Brittle. Sp. gr. 4.37. It dissolves with effervescence in acids. Its constituents are, oxide of bismuth 86.3, oxide of iron 5.2, carbonic acid 4.1, water 3.4. It occurs along with red cobalt. It is found at St. Agnes in Cornwall.

IV. CERIUM. See ALLANITE, CERITE, GADOLINITE, ORTHITE, YTTROCERITE. A fluate and subfluate of cerium have been also discovered at Finbo in Sweden.

V. COBALT ORES.

1. *Hexahedral cobalt pyrites*, or *silver-white cobalt.* Colour silver-white. Massive, and crystallized in the cube, octohedron, cube truncated, pentagonal, dodecahedron, icosahedron. Splendent, and metallic. Cleavage hexahedral. Fracture conchoidal. Semi-hard. Brittle. Streak gray. Sp. gr. 6.1 to 6.3. Before the blowpipe it gives out an arsenical odour; and, after being roasted, colours glass of borax smalt blue. Its constituents are, cobalt 44, arsenic 55, sulphur 0.5. Iron is sometimes present. It occurs in primitive rocks at Skutterend, in Norway. It is the principal ore of cobalt.

2. *Octohedral cobalt pyrites.*

a. The *tin-white;* of which there is the compact and radiated. The *compact* has a tin-white, and sometimes rather dark colour. It occurs massive and crystallized in the cube, octohedron, and rhomboidal dodecahedron, truncated on the six four-edged angles. Crystals generally rent and cracked.. Lustre splendent, metallic. Brittle. Sp. gr. 6.0 to 6.6. Its constituents are, arsenic 74.22, cobalt 20.3, iron 3.42, copper 0.16, sulphur 0.89. It occurs in granite, gneiss, &c. in Cornwall, Saxony, &c.

The *radiated;* colour tin-white, inclining to gray. Massive, and in distinct radiated concretions. Lustreglistening, metallic. Softer than the compact. Its constituents are, arsenic 65·75, cobalt 28, oxide of iron 5·0, oxide of manganese 1·25. It occurs in clay-slate at Schneeberg.

b. Gray octohedral cobalt pyrites. Colour light steel-gray. Massive, and tubiform. Dull, and tarnished externally. Internally splendent metallic. Fracture even. Streak shining. Brittle. When struck, emits an arsenical odour. Sp. gr 6·135. It contains 19·6 of cobalt, with iron and arsenic. It occurs in granite, gneiss, &c. It is found in Cornwall, Norway, &c. It affords a more beautiful blue smalt than any of the other cobalt minerals.

Cobalt-kies. Colour pale steel gray. Massive, and in cubes. Lustre metallic. Fracture uneven. Semi-hard. Its constituents are,

a. Radiated red cobalt, or *cobalt-bloom.* Colour crimson-red, passing into peach-blossom. Massive, imitative, and crystallized, in a rectangular four-sided prism, or a compressed acute double six-sided pyramid. Crystals acicular. Shining. Translucent. Rather sectile. Sp. gr. 4·0 to 4·3. It tinges borax-glass blue. Its constituents are, cobalt 39, arsenic acid 38, water 23. It occurs in veins in primitive, transition, and secondary rocks. It is found at Alva in Stirlingshire, in Cornwall, &c.

b. Earthy red cobalt, or *cobalt crust.* Colour peach-blossom red. Massive, and imitative. Friable. Dull. Sectile. Streak shining. Does not soil.

c. Slaggy red cobalt. Colour muddy crimson red. In crusts and reniform. Smooth. Shining. Fracture conchoidal. Translucent. Soft and brittle. It occurs at Furstemberg.

4. *Cobalt ochre.*

a. Black. The earthy-black has a dark brown colour; is friable, has a shining streak, and feels meagre. The indurated black has a bluish-black colour; occurs massive and imitative; has a glimmering lustre: fine earthy fracture; is opaque; soft; sectile; soils; sp. gr. 2 to 2·4. It consists of black oxide of cobalt, with arsenic and oxide of iron. These two sub-species occur usually together, in primitive or secondary mountains; at Alderly Edge, Cheshire, in red sandstone; at Howth, near Dublin, in slate-clay.

b. Brown cobalt-ochre. Colour liver-brown. Massive. Dull. Fracture fine earthy. Opaque. Streak shining; soft, sectile, light. It consists of brown ochre of cobalt, arsenic, and oxide of iron. It occurs chiefly in secondary mountains. It is found at Kamsdorf in Saxony.

c. Yellow cobalt-ochre. Colour muddy straw-yellow. Massive and incrusting. Rent. Dull. Fracture fine earthy. Streak shining. Soft and sectile. Sp. gr. 2.67, after absorbing water. It is the purest of the cobalt ochres. It is found with the preceding. It contains silver.

5. *The sulphate of cobalt* is found at Biber, near Hannau, in Germany. It consists of sulphuric acid 19·74, oxide of cobalt 38·71, water 41·55. It has a light flesh-red colour; and a stalactical form. Streak yellowish-white. Taste styptic.

VI. COPPER ORES.

1. *Octohedral* or *native copper.* Colour copper-red, frequently incrusted with green. Massive, imitative, and crystallized; in the perfect cube; the cube truncated, on the angles, on the edges, and on the edges and angles; the garnet dodecahedron; perfect octohedron; and rectangular four-sided prism. Lustre glimmering, metallic. Fracture hack-

ly. Streak splendent, metallic. Harder than silver. Completely malleable. Flexible, but not elastic. Difficultly frangible. Sp. gr. 8·4 to 8·7. It consists of 99·8 of copper, with a trace of gold and iron. It occurs in veins, in granite, gneiss, &c. and is found chiefly in Cornwall.

2. *Octohedral red copper ore.*

a. Foliated red copper ore. Colour dark cochineal-red. Massive, and crystallized, in the perfect octohedron, which is the primitive form; in the octohedron, truncated on the angles; on the edges, with each angle acuminated with four planes; bevelled on the edges, and each angle acuminated with eight planes. Lustre adamantine, inclining to semi-metallic. Cleavage fourfold. Translucent on the edges, or translucent. Streak muddy tile-red. Hardness between calcareous and fluor-spar. Brittle. Sp. gr. 5·6 to 6·0.

b. Compact red copper ore. Colour between lead-gray and cochineal-red. Massive and reniform. Lustre semi-metallic. Fracture even. Opaque. Streak tile-red. Brittle.

c. Capillary red copper ore. Colour carmine-red. In small capillary crystals. Lustre adamantine. Translucent.

The whole of these red ores are deutoxides of copper, and are easily reduced to the metallic state before the blowpipe. They dissolve with effervescence when thrown in powder into nitric acid; and a green nitrate results. In muriatic acid no effervescence takes place. They occur principally in veins that traverse primitive and transition rocks; abundantly in the granite of Cornwall. The earthy red copper ore, which is rare, is a sub-species of the preceding.

d. Tile ore. The *earthy* tile ore has a hyacinth-red colour. It occurs massive and incrusting copper pyrites. It is composed of dull dusty particles. It soils slightly, and feels meagre. It occurs in veins, as at Lauterberg in the Hartz. The *indurated* tile ore has an imperfect flat conchoidal fracture; a streak feebly shining; and is intermediate between semi-hard and soft. It is an intimate combination of red copper ore and brown iron ochre, containing from 10 to 50 per cent. of copper.

3. *Black copper, or black oxide of copper.* Colour between bluish and brownish-black. It occurs massive, and thinly coating copper pyrites. It is composed of dull pasty particles, which scarcely soil. Streak slightly shining. Before the blowpipe it emits a sulphureous odour, melts into a slag, and communicates a green colour to borax. It is said to be an oxide of copper with oxide of iron. It occurs at Carharrack and Tincroft mines, in Cornwall.

4. *Emerald copper* or *dioptase.* Colour emerald-green. It occurs only crystallized. The primitive form is a rhomboid of 123° 58′. The only secondary form at present known is the equiangular six-sided prism. Lustre shining pearly. Cleavage threefold. Fracture small conchoidal. Translucent. As hard as apatite. Brittle. Sp. gr. 3.3. It becomes a chesnut-brown before the blowpipe, and tinges the flame green, but is infusible; with borax it gives a bead of copper. Its constituents are, oxide of copper 28·57, carbonate of lime 42·83, silica 28·57.—*Vauq.* By Lowitz, it consists of 55 oxide of copper, 33 silica, and 12 water, in 100. It is found in the land of Kirguise, 125 leagues from the Russian frontier, where it is associated with malachite and limestone.

5. *Blue copper*, or *prismatic malachite*, of which there are two kinds,—the radiated and earthy.

a. The *radiated* has an azure-blue colour. Massive, imitative, and crystallized. Its primitive form is an oblique prism. The secondary forms are, an oblique four-sided prism, variously bevelled, and a rectangular four-sided prism, or eight-sided prism, acuminated with four planes. Lustre vitreous. Cleavage threefold. Fracture imperfect conchoidal. Translucent. Colour of the streak, lighter. Harder than calcareous spar. Brittle. Sp. gr. 3·65. It is soluble with effervescence in nitric acid. With borax it yields a metallic globule, and colours the flux green. Its constituents are, copper 56, carbonic acid 25, oxygen 12·5, water 6·5. —*Vauquelin.* It is found at Leadhills in Dumfries-shire, and Wanlockhead in Lanarkshire, and at Huel-Virgin and Carharrack in Cornwall, and in many places on the continent.

b. Earthy blue copper. Colour smalt-blue. Massive. Friable. Sp. gr. 3·354. It is found in Norway, &c.

The velvet-blue copper belongs to the same species. Lustre glistening and pearly. It has been found only at Oravicza in the Bannat, along with malachite and the brown ironstone.

6. *Malachite*; of which there are, the fibrous and compact.

a. Fibrous malachite. Colour perfect emerald green. Imitative, and crystallized, in oblique four-sided prisms, variously bevelled or truncated; and in an acute-angular three-sided prism. Crystals short, capillary, and acicular. Lustre pearly or silky. Translucent, or opaque. Softer than blue copper. Streak pale green. Brittle. Sp. gr. 3·66. Before the blowpipe it decrepitates, and becomes black. Its constituents are, copper 58, carbonic acid 18, oxygen 12·5, water 11·5.—*Klaproth.* It occurs principally in veins. It is found at Sandlodge in Mainland, one of the Shetlands; at Landidno in Caernarvonshire; and in the mines of Arendal in Norway.

b. Compact malachite. Colour emerald-green. Massive, imitative, and in four-sided prisms. Glimmering and silky. Fracture small grained uneven. Opaque. Streak pale green. Sp. gr. 3·65. In veins, which traverse different rocks in Cornwall, Norway, &c. *Brown copper* from Hindostan is placed after this mineral by Professor Jameson. Its colour is dark blackish-brown. Massive. Soft. Sp. gr. 2·62. It effervesces in acids, letting fall a red powder. Its constituents are, carbonic acid 16·7, deutoxide of copper 60·75, deutoxide of iron 19·5, silica 2·1.—*Dr. Thomson.*

7. *Copper-green.*

Common copper green, or *chrysocolla*, contains three sub-species.

a. Conchoidal copper-green. Colour verdigris-green. Massive, imitative, and incrusting. Glistening. Fracture conchoidal. Translucent. Harder than gypsum. Easily frangible. Sp. gr. 2·0 to 2·2. It becomes black and then brown before the blowpipe, but does not fuse. It melts and yields a metallic globule with borax. Its constituents are, copper 40, oxygen 10, carbonic acid 7, water 17, silica 26.—*Klaproth.* It accompanies malachite. It is found in Cornwall, &c.

Siliceous copper, or *kieselkupfer*, is a variety of the above. Colour asparagus-green. In crusts. Glistening. Fracture even or earthy. Opaque. Soft. Its constituents are, copper 37·8, oxygen 8, water 21·8, silica 29, sulphate of iron 3.

b. Earthy iron-shot copper-green. Colour olive-green. Massive, and in crusts. Friable. Opaque. Sectile.

c. Slaggy iron-shot copper-green. Colour blackish-green. Massive. Glistening. Fracture conchoidal. Opaque. Soft. Easily frangible. It is probably a compound of conchoidal copper-green and oxide of iron. Both occur together, and pass into each other. It occurs in Cornwall, along with olivenite.

8. *Prismatic vitriol, blue vitriol*, or *sulphate of copper.* Colour dark sky-blue. Massive, imitative, and crystallized. The primitive figure is an oblique four-sided prism, in which the lateral edges are 124° 2′, and 55° 58′; with edges and angles often truncated. Shining. Cleavage double. Fracture conchoidal. Translucent. Harder than gypsum. Sp. gr. 2·1 to 2·2. Taste nauseous, bitter, and metallic. Its solution coats iron with metallic copper. Its constituents are, oxide of copper 32·13, sulphuric acid 31·57, water 36·3.—*Berzelius.* It occurs along with copper pyrites, in Pary's mine in Anglesea, and in Wicklow.

9. *Prismatic olivenite*, or *phosphate of copper.* Colour emerald-green. Massive, and in oblique four-sided prisms of 110°. Cleavage double oblique. Glistening. Fracture splintery. Opaque. Streak verdigris-green. As hard as apatite. Brittle. Sp. gr. 4 to 4·3. Fuses into a brownish globule. Its constituents are, oxide of copper 68·13, phosphoric acid 30·95. It is found at Virneberg on the Rhine, along with quartz, red copper ore, &c.

10. *Diprismatic olivenite*, or *lenticular copper.* Colour sky-blue. Massive, but generally crystallized. In very oblique four-sided prisms, bevelled; in rectangular double four-sided pyramids; shining; fracture uneven; translucent. Harder than gypsum. Brittle. Sp. gr. 2·85. Converted by the blowpipe into a black friable scoria. Its constituents are, oxide of copper 49, arsenic acid 14, water 33.—*Chenevix.* Found in Cornwall.

11. *Acicular olivenite. a. Radiated* or *cupreous arseniate of iron.* Colour dark verdigris-green. Massive, imitative, and in flat oblique four-sided prisms, acuminated or truncated. Lustre glistening pearly. Translucent on the edges. As hard as calcareous spar. Brittle. Sp. gr. 3·4.

b. Foliated acicular olivenite; arseniate of copper. Colour dark olive green. In angulo-granular concretions, and in small crystals; which are oblique four-sided prisms; and acute double four-sided pyramids. Glistening. Fracture conchoidal. Translucent. Streak olive-green. As hard as calcareous spar. Brittle. Sp. gr. 4·2 to 4·6. It boils, and gives a hard reddish-brown scoria before the blowpipe. Its constituents are, oxide of copper 60, arsenic acid 39·7.—*Chenevix.* In the copper mines of Cornwall.

c. Fibrous acicular olivenite. Colour olive-green. Massive, reniform, and in capillary and acicular oblique four-sided prisms. Glistening and pearly. Opaque. As hard as calc-spar. Brittle. Fibres sometimes flexible. Streak brown or yellow. Sp. gr. 4·1 to 4·2. Its constituents are, oxide of copper 50, arsenic acid 29, water 21. It occurs in Cornwall.

d. Earthy acicular olivenite. Colour olive-green. Massive and in crusts. Dull. Fracture fine earthy. Opaque. Very soft. It is found in Cornwall.

12. *Atacamite*, or *muriate of copper.*

a. Compact. Colour leek-green. Massive, and in short needle-shaped crystals, which are oblique four-sided prisms, bevelled or truncated. Shining and pearly. Translucent on the edges. Soft. Brittle. Sp. gr. 4.4 ? It tinges the flame of the blowpipe of a bright green and blue, muriatic acid rises in vapours, and a bead of copper remains on the charcoal. It dissolves without effervescence in nitric acid. Its constituents are, oxide of copper 73·0, water 16·9, muriatic acid 10·1.—*Klaproth.* It occurs in veins in Chili and Saxony.

b. Arenaceous atacamite, or *copper-sand.* Colour grass-green. In glistening scaly particles. It does not soil. It is translucent. Its constituents are, oxide of copper 63, water 12, muriatic acid 10, carbonate of iron 1, mixed siliceous sand 11. It is found in the sand of the river Lipes, 200 leagues beyond Copiapu, in the desert of Atacama, which separates Chili from Peru.

13. *Copper pyrites.*

a. Octohedral copper pyrites. On the fresh fracture, its colour is brass-yellow; but it is usually tarnished. Massive, imitative, and crystallized; in a regular octohedron, perfect, truncated or bevelled; and in a perfect or truncated tetrahedron. Glistening. Fracture uneven. Hardness from calcareous to fluor spar. Brittle. Sp. gr. 4·1 to 4·2. Before the blowpipe, on charcoal, it decrepitates, emits a greenish-coloured sulphureous smoke, and melts into a black globule, which assumes metallic lustre. It tinges borax green. I's constituents are, copper 30, iron 53, sulphur 12.—*Chenevix.* It contains sometimes a little gold or silver. It occurs in all the great classes of rocks. It is found near Tynedrum in Perthshire; at the mines of Ecton; at Pary's mountain; abundantly in Cornwall; and in the county of Wicklow in Ireland. The rich ores are worked for copper; the poor, for sulphur.

b. Tetrahedral copper pyrites; of which species there are two sub-species, gray copper and black copper.

Gray copper. Colour steel-gray. Massive and crystallized. In the tetrahedron, truncated or bevelled; and in the rhomboidal dodecahedron. Splendent. Fracture uneven. Hardness as calcareous spar and fluor. Brittle. Sp. gr. 4·4 to 4·9. Its constituents are, copper 41, iron 22·5, sulphur 10, arsenic 24·1, silver 0·4.—*Klaproth.* It occurs in beds and veins in Cornwall, and many other places.

Black copper. Colour iron-black. Massive and crystallized; in the tetrahedron, perfect, bevelled, or truncated. Splendent. Fracture conchoidal. Brittle. Spec. grav. 4.85. Its constituents are, copper 39, antimony 19.5, sulphur 26, iron 7.5, mercury 6.25.—*Klaproth.* The mercury is accidental. It occurs in veins in the Hartz, and in Peru.

14. *White copper.* Colour between silver-white and brass-yellow. Massive and disseminated. Glistening and metallic. Fracture uneven. Semi-hard. Brittle. Spec. grav. 4.5. It yields before the blowpipe a white arsenical vapour, and melts into a grayish-black slag. It contains 40 per cent. of copper, the rest being iron, arsenic, and sulphur. It occurs in primitive and transition rocks. It is found in Cornwall and Saxony.

15. *Copper-glance,* or *vitreous copper.*

Rhomboidal copper-glance.

§ 1. Compact. Colour blackish lead-gray. Massive, in plates and crystallized. Primitive form, a rhomboid. Secondary forms, a low equiangular six-sided prism, and a double six-sided pyramid. Glistening, metallic. Harder than gypsum. Perfectly sectile. Rather easily frangible. Spec. grav. 5.5 to 5.8. Its constituents are, copper 78.05, iron 2.25, sulphur 18.5, silica 0.75.—*Klaproth.*

§ 2. *Foliated.* Its constituents are, copper 79.5, sulphur 19, iron 0.75, quartz 1.—*Ullmann.* It occurs in primitive rocks. It is found also in transition rocks, at Fassney-burn in East-Lothian; in Ayrshire; at Middleton Tyas in Yorkshire; in Cornwall, &c.

16. *Variegated copper.* Colour between copper-red and pinchbeck-brown. Massive, in plates, and crystallized in six sided prisms. Glistening, metallic. Soft. Easily frangible. Spec. grav. 5. It is fusible, but not so easily as copper-glance, into a globule, which acts powerfully on the magnetic needle. Its constituents are, copper 69.5, sulphur 19, iron 7.5, oxygen 4.—*Klaproth.* It occurs in gneiss, mica slate, &c. It is found in Cornwall.

VII. Gold Ores.

1. *Hexahedral,* or *native gold.*

a. Gold-yellow native gold. Colour perfect gold-yellow. Disseminated, in grains, and crystallized; in the octohedron, perfect or truncated; in the cubo-octohedron; in the cube, perfect or truncated; in the double eight-sided pyramid; in the tetrahedron, and rhomboidal dodecahedron. Splendent. Fracture, fine hackly. Soft. Difficultly frangible. Malleable. Spec. grav. from 17 to 19, and so low as 12. Fusible into a globule. It is gold with a very minute portion of silver and copper. It occurs in many very different rocks; and in almost every country. See an extensive enumeration of localities, in Jameson's Mineralogy.

b. Brass-yellow native gold, occurs capillary; in octohedrons, and in six-sided tables. Spec. grav. 12.713. Its constituents are, gold 96.9, silver 2, iron 1.1. It is found in the gold mines of Hungary, in Siberia, &c.

c. Grayish-yellow native gold. Colour brass-yellow verging on steel-gray. In small flattish grains. Never crystallized. It is said to contain platina. It is rather denser than the last. It occurs along with platina and magnetic iron-ore in South America.

d. Argentiferous gold, or *electrum.* Colour pale brass-yellow. In small plates, and imperfect cubes. Its constituents are, 64 gold, 36 silver. It occurs along with massive heavy spar in Siberia. Klaproth says, it is acted on neither by nitric nor nitro-muriatic acid. See Tellurium Ores.

VIII. Iridium Ore. Colour pale-steel gray. In very small irregular flat grains. Lustre shining and metallic. Fracture foliated. Brittle. Harder than platina. Spec. grav. 19.5. By fusion with nitre, it acquires a dull black colour, but recovers its original colour and lustre, by heating with charcoal. It consists of iridium, with a portion of osmium. It occurs in alluvial soil in South America, along with platina.—*Wollaston.*

IX. Iron Ores.

I. *Native,* or *octohedral iron.*

a. Terrestrial native iron. Colour steel-gray. Massive, in plates and leaves. Glistening and metallic. Fracture hackly. Opaque. Malleable. Hard. Magnetic. Its constituents are, iron 92.5, lead 6, copper 1.5.—*Klaproth.* It is found with brown iron-stone and quartz in a vein, in the mountain of Oulle, in the vicinity of Grenoble, &c.

b. Meteoric native iron. Colour pale steel-gray, inclining to silver-white. Generally covered with a thin brownish crust of oxide of iron. It occurs ramose, imperfect globular, and disseminated in meteoric stones. Surface, smooth and glistening. Internally, it is intermediate between glimmering and glistening, and the lustre is metallic. Fracture hackly. Fragments blunt-edged. Yields a splendent streak. Intermediate between soft and semi-hard. Malleable. Flexible, but not elastic. Very difficultly frangible. Spec. grav. 7.575. Its constituents are—

	Agram.	Arctic.	Mexico.	Siberia.
Iron,	96·5	97	96·75	90·54
Nickel,	3·5	3	3·25	9·46
	100·0	100	100·00	100·00
	Klapr.	*Brande.*	*Klapr.*	*Children.*

The American native iron contains 0.10 of nickel; the Siberian 0.17; and the Senegambian 0.05 and 0.06.—*Howard.* It appears to be formed in the atmosphere, by some process hitherto unknown to us. See Meteorolite, and *Jameson's Mineralogy*, iii. p. 101.

II. *Iron ore.*

a. Octohedral iron ore, of which there are three kinds.

§ 1. *Common magnetic iron ore.* Colour iron-black. Massive, in granular concretions, and crystallized; in the octohedron, truncated, bevelled, and cuneiform; rhomboidal dodecahedron; rectangular four-sided prism; cube; tetrahedron; equiangular six-sided table; and twin crystal. Splendent and metallic. Cleavage fourfold. Fracture uneven. Streak black. Harder than apatite. Brittle. Spec. grav. 4.8 to 5.2. Highly magnetic, with polarity. Before the blowpipe it becomes brown, and does not melt; it gives glass of borax a dark green colour. Its constituents are, peroxide of iron 69, protoxide of iron 31.—*Berzelius.* It occurs in beds of great magnitude, in primitive rocks, at Unst; at St. Just in Cornwall; at Arendal in Norway, &c. It affords excellent bar-iron.

§ 2. *Granular magnetic iron ore*, or *iron-sand.* Colour very dark iron-black. In small grains and octohedral crystals. Glimmering. Fracture conchoidal. Brittle. Streak black. Spec. grav. 4 6 to 4.8. Magnetical with polarity. Its constituents are, oxide of iron 85·5, oxide of titanium 14, oxide of manganese 0·5.—*Klaproth.* It occurs imbedded in basalt, &c. It is found in Fifeshire, in the Isle of Skye, in the river Dee in Aberdeenshire, &c.

§ 3. *Earthy magnetic iron ore.* Colour bluish-black. In blunt-edged rolled pieces. Dull. Fracture fine grained uneven. Opaque. Soft. Streak black, shining. Soils. Sectile. It emits a faint clayey smell when breathed on. Sp. gr. 2·2. It occurs in the iron mines of Arendal in Norway.

b. Rhomboidal iron ore; of which there are three sub-species.

§ 1. *Specular iron ore*, *iron glance*, or *fer oligiste* of the French. Of this there are two kinds, the common and micaceous. *Common specular iron ore.* Colour dark steel-gray. Massive, disseminated, and crystallized. Prim. form, a rhomboid, or double three-sided pyramid, in which the angles are 87° 9′, and 92° 51′. The secondary figures are, the primitive form variously bevelled, truncated, and acuminated; the flat rhomboid; equiangular six-sided table; low equiangular six-sided prism; and very acute six-sided pyramid. Lustre, splendent metallic. Cleavage threefold. Fracture imperfect conchoidal. Streak cherry-red. Hardness between felspar and quartz. Rather difficultly frangible. Sp. gr. 5·2. Magnetic in a slight degree. Its constituents are, red-dish-brown oxide of iron 94.38, phosphate of lime 2.75, magnesia 0.16, mineral oil 1.25 ?—*Hisinger.* It occurs in beds in primitive mountains. It is found at Cumberhead in Lanarkshire; at Norberg in Westmannland, in Norway, &c. It affords an excellent malleable iron.

Micaceous specular iron ore. Colour iron-black. Massive, disseminated, and in small thin six-sided tables, intersecting one another so as to form cells. Splendent, metallic. Cleavage single curved-foliated. Translucent in thin plates. Streak cherry-red. As hard as the above. Most easily frangible. Spec. grav. 5.07. It slightly affects the magnet. It is peroxide of iron. It occurs in beds in mica-slate. It is found at Dunkeld and Benmore in Perthshire; in several parts of England and Norway, &c. The iron it affords is sometimes cold short, but is well fitted for cast ware. It is characterized by its high degree of lustre, openness of its cleavage, and easy frangibility. It affords from 70 to 80 per cent of iron.

§ 2. *Red iron ore*; of which there are four kinds, the scaly, ochry, compact, and fibrous.

Scaly red iron ore, or *red iron froth.* Colour dark steel-gray to brownish-red. Friable, and consists of semi-metallic shining scaly parts, which are sometimes translucent and soil strongly. It constituents are, iron 66, oxygen 28.5, silica 4.25, alumina 1.25—*Henry.* But Bucholz found it to be a pure red oxide of iron, mixed with a little quartz sand. It occurs in veins in primitive rocks. It is found at Ulverstone in Lancashire; in Norway, &c.

Ochry red iron ore, or *red ochre.* Colour brownish red. Friable. Dusty dull particles. Soils. Streak, blood-red. Easily frangible. Spec. grav. 2.947. It occurs in veins, with the preceding ore. It melts more easily than any of the other ores of this metal, and affords excellent malleable iron.

Compact red iron ore. Colour between dark steel-gray and blood-red. Massive, and in supposititious crystals; which are an acute double six-sided pyramid from calcareous spar; and a cube from fluor spar and iron pyrites.

Lustre metallic. Fracture even. Streak pale blood-red. Easily frangible. Spec. gravity, 4.232. When pure it does not affect the magnet. Its constituents are, oxide of iron 70.5? oxygen 29.5?—*Bucholz.* It occurs in beds and veins in gneiss, &c. It affords good bar and cast-iron.

Fibrous red iron ore, or *red hematite.* Colour between brownish-red and dark steel-gray. Massive, imitative, and in supposititious double six-sided pyramids from calcareous spar. Glistening, semi-metallic. Opaque. Streak blood-red. Brittle. Spec. gravity 4.74. Its constituents are, 90 oxide of iron, silica 2, lime 1, water 3.—*Daubuisson.* It occurs with the compact. It affords excellent malleable and cast-iron. Its powder is used for polishing tin, silver, and gold vessels, and for colouring iron brown.

§ 3. *Red clay iron ore or stone;* of which the varieties are, the ochry, the columnar, the lenticular, and jaspery. The first is used for red crayons, and is called red chalk. It occurs in Hessia, &c. The second consists of 50 oxide of iron, 13 water, 32 silica, and 7 alumina.—*Brocchi.* It is rare, and is called a pseudo-volcanic product. It affords excellent iron. It consists of oxide of iron 64, alumina 23, silica 7·5, water 5. The jaspery is found in Austria.

c. Prismatic iron ore, or *brown iron stone.* Of this we have four sub-species.

§ 1. *Ochry brown iron ore.* Yellowish-brown. Massive; dull. Fracture, earthy; soils. Soft; sectile. Its constituents are, peroxide of iron 83, water 12, silica 5. It occurs with the following.

§ 2. *Compact.* Colour passes to clove-brown. Massive, and in supposititious crystals from pyrites. Dull. Brittle. Sp. gr. 3 to 3·7. It contains 84 peroxide of iron, 11 water, and 2 silica. It affords about 50 per cent. of good bar iron.

§ 3. *Fibrous.* Clove-brown. Imitative; and in supposititious crystals. Splendent externally. Glimmering internally. Opaque. Harder than apatite. Brittle. Sp. gr. 3·9. Streak pale yellowish-brown. Its constituents are, 80·25 oxide of iron, 15 water, 3·75 silica. —*Vauquelin.*

The preceding sub-species occur most frequently in transition and secondary mountains. They are found in veins in sand-stone, along with heavy spar, at Cumberhead in Lanarkshire, &c. They melt easily, and afford from 40 to 60 per cent. of good bar, but indifferent cast-iron. Good steel may be made from it.

§ 4. *Brown clay iron ore;* of which there are five kinds, the common, the pisiform, the reniform, the granular, and umber.

The *first* occurs massive; has a flat conchoidal fracture; a brown streak; and is soft. It contains 69 oxide of iron, 3 manganese, 13 water, 10 silica, and 3 alumina. The *second* has a yellowish-brown colour. It occurs in small solid spherical grains, composed of concentric concretions. Sp. gr. 3·142. It consists of 48 oxide of iron, 31 alumina, 15 silica, and 6 water.—*Vauquelin.* It is found in hollows in shell limestone, at Galston in Ayrshire, &c. It yields from 40 to 50 per cent. of iron; and in Dalmatia it is used as small shot. The *third* has a yellowish-brown colour. Massive, and imitative; in concentric lamellar concretions, which often include a loose nodule. Glimmering. Sectile. Its constituents are, peroxide of iron 76, water 14, silica 5, oxide of manganese 2. It occurs in iron-shot clay in secondary rocks. It is found in East and Mid-Lothian, in Colebrookdale, &c. It yields an excellent iron. The *fourth*, or granular, occurs massive and in grains. Fracture thick slaty. Streak yellowish-brown. Soft. Brittle. Sp. gr. 3. It occurs in beds between the red limestone of the salt formation, and the lias limestone. It is found in Bavaria, France, &c. It affords about 40 per cent. of good iron. *Fifth*, *Umber.* Colour clove-brown. Massive. Dull. Fracture flat conchoidal. Soft. Sectile. Soils strongly. Feels meagre. Adheres strongly to the tongue, and readily falls to pieces in water. Sp. gr. 2·06. It consists of oxide of iron 48, oxide of manganese 20, silica 13, alumina 5, water 14.—*Klaproth.* It occurs in beds in the island of Cyprus. It is used as a pigment.

Bog iron ore is arranged as a variety of the above. There are three kinds of it:

§ 1. *Meadow ore*, or *friable bog iron ore.* Colour pale yellowish-brown. Friable. Dull. Fracture, earthy. Soils. It feels meagre, but fine.

§ 2. *Swamp ore*, or *indurated bog iron ore.* Colour dark yellowish-brown. Corroded and vesicular. Dull. Earthy. Very soft. Sectile. Sp. gr. 2·944.

§ 3. *Meadow ore*, or *conchoidal bog iron ore.* Blackish-brown. Massive, and tuberose. Glistening. Fracture, small conchoidal. Streak yellowish-gray. Soft. Sp. gr. 2·6. Its constituents are, oxide of iron 66, oxide of manganese 1·5, phosphoric acid 8, water 23. —*Klaproth.* By Vauquelin's experiments it seems to contain also chrome, magnesia, silica, alumina, and lime; zinc and lead are likewise occasionally present. It belongs to a recent formation, Werner's ingenious theory of which is given by Professor Jameson, vol. xiii. p. 247. It is found in the Highlands of Scotland, in Saxony, &c. The second is most easily reduced, and affords the best iron.

Pitchy iron ore may also be placed here. Its colour is blackish-brown. Massive. Glistening. Fracture flat conchoidal. Translucent on the edges. Hard. Streak yellowish-gray. Brittle. Sp. gr. 3·562. Its constituents are, phosphoric acid 27, manganese 42, oxide of iron 31.—*Vauquelin.* It occurs near Limoges in France.

Iron sinter. Colour brown. Massive and imitative. Glistening. Fracture flat conchoidal. Translucent. Soft. Brittle. Sp. gr. 2·4. Its constituents are, water 25, oxide of iron 67, sulphuric acid 8.—*Klaproth*. It occurs in the galleries of old mines in Saxony and Silesia.

III. *Iron pyrites.*

§ 1. *Hexahedral* or *common iron pyrites.* Colour perfect bronze-yellow. Massive, imitative, and crystallized; in cubes, variously bevelled. Lustre from specular-splendent, to glistening and metallic. Cleavage hexahedral. Fracture uneven. Harder than felspar, but softer than quartz. Brittle. When rubbed it emits a strong sulphureous smell. Sp. gr. 4·7 to 5. It burns with a bluish flame and sulphureous odour before the blowpipe. It afterwards changes into a brownish-coloured globule, which is attractible by the magnet. Its constituents are, sulphur 52·5, iron 47·5.—*Hatchett.* Silver and gold are occasionally present. It occurs in beds in various mountains. It is worked for sulphur or copperas.

§ 2. *Prismatic iron pyrites.*

a. Radiated pyrites. Colour pale bronze-yellow. Most usually imitative, or crystallized. Primitive form, is an oblique four-sided prism, in which the obtuse angle is 106° 36′. Secondary forms are, the above variously bevelled; and the wedge-shaped double four-sided pyramid. Harder than felspar. Sp. gr. 4·7 to 5·0. Its constituents are, sulphur 53·6, iron 46·4.—*Hatchett.* It is much rarer than the preceding. It is found in Cornwall, Isle of Sheppy, &c.

b. Hepatic or *liver pyrites.* Colour pale brass-yellow. Massive and imitative. Glimmering and metallic. Fracture uneven. Sp. gr. 4·834. It occurs in veins in primitive rocks. It is found in Derbyshire, &c.

c. Cellular pyrites. Colour bronze-yellow. Cellular. Surface of the cells drusy. Fracture flat conchoidal. It occurs in veins at Johanngeorgenstadt in Saxony.

d. Spear pyrites. Colour between bronze-yellow and steel-gray. Crystallized in twin or triple crystals. Fracture uneven. It occurs in veins in primitive rocks, associated with brown coal.

e. Cockscomb pyrites. Colour as above. Crystallized in double four-sided pyramids. Glistening and metallic. It occurs in Derbyshire.

§ 3. *Rhomboidal iron pyrites* or *magnetic pyrites.*

a. Foliated magnetic. Colour between bronze-yellow and copper-red. Massive, and sometimes crystallized, in a regular six-sided prism, truncated; and in a six-sided pyramid. Splendent and metallic. Sp. gr. 4·4 to 4·6. It occurs in Saxony.

b. Compact magnetic. Same colour. Massive. It affects the magnetic needle. Its constituents are, sulphur 36.5, iron 63·5.—*Hatchett.* It is found in Galloway and Caernarvonshire.

IV. *Native salts of iron.*

a. The *Prismatic chrome-ore.* Colour between steel-gray and iron-black. Massive, and in oblique four-sided prisms, acuminated with four planes. Lustre imperfect metallic. Fracture small grained uneven. Opaque. Hardness, between apatite and felspar. Streak dark brown. Sp. gr. 4·4 to 4·5. Some varieties are magnetic, others not. It is infusible before the blowpipe. With borax, it forms a beautiful green-coloured mass. The constituents of the French are, oxide of iron 34·7, oxide of chrome 43, alumina 20·3, silica 2.—*Haüy.* The Siberian contains 34 oxide of iron, 53 oxide of chrome, 11 alumina, 1 silica, and 1 manganese.—*Laugier.* It occurs in primitive serpentine. It is found in the islands of Unst and Fetlar, in Scotland; and also at Portsoy in Banffshire. In considerable quantity in serpentine on the Bare-hills near Baltimore.

b. Sparry iron, or *carbonate of iron.* Colour pale yellowish-gray. Massive, disseminated and crystallized. The primitive form is a rhomboid of 107°. The following are some of the secondary forms:—the primitive rhomboid, perfect or truncated; a still flatter rhomboid; the spherical lenticular form; the saddle-shaped lens; the equiangular six-sided prism. Glistening and pearly. Cleavage threefold. Fracture foliated. Translucent on the edges, or opaque. Streak white or yellowish-brown. Harder than calcareous spar. Sp. gr. 3·6 to 3·9. It blackens and becomes magnetic before the blowpipe. It effervesces with muriatic acid. Its constituents are, oxide of iron 57·5, carbonic acid 36, oxide of manganese 3·5, lime 1·25.—*Klaproth.* It occurs in veins in granite, and in limestone. In small quantities in Britain. In great quantity at Schmalkalden in Hessia. It affords an iron well suited for making steel.

c. Rhomboidal vitriol, or *green vitriol.* Colour emerald-green. Primitive form of the crystals is a rhomboid, with edges of 81° 23′ and 98° 37′; and plane angles of 100° 10′ and 79° 50′. Vitreous or pearly lustre. Cleavage threefold. Fracture flat conchoidal. Semi-transparent. Refracts double. As hard as gypsum. Sp. gr. 1·9 to 2·0. Taste sweetish, styptic, and metallic. Before the blowpipe, on charcoal, it becomes magnetic. Its constituents are, oxide of iron 25·7, sulphuric acid 28·9, water 45·4.—*Berzelius.* It results from the decomposition of iron pyrites.

d. Arseniate of iron. See CUBE ORE.

e. Blue iron, or *phosphate of iron.*

Prismatic blue iron.

§ 1. *Foliated blue iron.* Colour dark indigo-blue. Primitive form an oblique four-sided prism. The secondary forms are, a broad rectangular four-sided prism, truncated; and an eight-sided prism. Shining. Cleavage straight, single. Translucent. As hard as gypsum. Streak paler blue. Sectile, and easily frangible. Flexible in thin pieces. Sp. gr. 2·8 to 3·0. Its constituents are, oxide of iron 41·25, phosphoric acid 19·25, water 31·25, iron-shot silica 1·25, alumina 5.—*Fourcroy* and *Laugier*. It occurs in St. Agnes's in Cornwall.

§ 2. *Fibrous blue iron*. Colour indigo-blue. Massive, and in delicate fibrous concretions. Glimmering and silky. Opaque. Soft. It occurs in syenite at Stavern in Norway.

§ 3. *Earthy blue iron*. Colour as above. Friable, and in dusty particles. Soils slightly. Rather light. Before the blowpipe it loses its blue colour, becomes reddish-brown, and lastly melts into a black-coloured slag, attractible by the magnet. Its constituents are, oxide of iron 47, phosphoric acid 32, water 20.—*Klaproth*. It occurs in nests in clay-beds. In several of the Shetland islands, and in river mud at Toxteth, near Liverpool.

4. *Tungstate of iron*. See ORES of TUNGSTEN.

5. *Blue ironstone*. Colour indigo-blue. Massive, and with impressions of crystals of brown iron ore. Glimmering, or dull. Fracture coarse grained uneven. Opaque. Semi-hard. Rather brittle. Sp. gr. 3·2.—*Klaproth*. It loses its colour by heat; and with borax forms a clear bead. Its constituents are, oxide of iron 40.5, silica 50, lime 1·5, natron 6, water 3. It occurs on the banks of the Orange River in South Africa.

X. LEAD ORES.

1. *Galena*, or *lead-glance*.

Hexahedral galena.

§ 1. *Common*. Colour fresh lead-gray. Massive, imitative, and crystallized in cubes, octohedrons, rectangular four-sided prisms, broad unequiangular six-sided prisms, six-sided tables, and three-sided tables. Specular splendent, to glimmering. Lustre metallic. Cleavage hexahedral. Fragments cubical. Harder than gypsum. Sectile and frangible. Sp. gr. 7 to 7·6. Before the blowpipe it flies in pieces, then melts, emitting a sulphureous odour, while a globule of lead remains. Its constituents are, lead 83, sulphur 16·41, silver 0·08.—*Westrumb*. It occurs in beds, &c. in various mountain rocks; at Leadhills in Lanarkshire, &c. Nearly all the lead of commerce is obtained from galena. The ore is roasted and then reduced with turf.

§ 2. *Compact galena*. Colour somewhat darker than the preceding. Massive, shining, metallic. Fracture flat conchoidal. Streak more brilliant. It consists of sulphuret of lead, sulphuret of antimony, and a small portion of silver. It is found at Leadhills in Lanarkshire, in Derbyshire, &c.

§ 3. *Friable galena*. Colour dark fresh lead-gray. Massive and in thick flakes. Sectile. It is found only around Freyberg.

Blue lead. Colour between very dark indigo-blue and dark lead-gray. Massive, and crystallized in regular six-sided prisms. Feebly glimmering. Soft. Sectile. Sp. gr. 5·461. It is conjectured to be sulphuret of lead, intermixed with phosphate of lead. It occurs in veins. It has been found in Saxony and France.

Cobaltic galena. Colour fresh lead-gray. Minutely disseminated in exceedingly small crystals, aggregated in a moss-like form. Shining and metallic. Scaly foliated. Opaque. Soft. Soils feebly. It communicates a smalt-blue colour to glass of borax. It occurs near Clausthal in the Hartz.

2. *Lead spar*.

§ 1. *Triprismatic lead spar*, or *sulphate of lead*. Colours yellowish and grayish-white. Massive and crystallized. In the primitive form the vertical prism is 120°. The principal crystallizations are, an oblique four-sided prism, variously bevelled or truncated; and a broad rectangular four-sided pyramid. Lustre shining, adamantine. Fracture conchoidal. Translucent. As hard as calcareous spar. Streak white. Brittle. Sp. gr. 6.3. It decrepitates before the blow-pipe, then melts, and is soon reduced to the metallic state. Its constituents are, oxide of lead 70.5, sulphuric acid 25.75, water 2.25.—*Klavroth*. It occurs in veins along with galena at Wanlockhead in Dumfries-shire, Leadhills, Pary's mine, and Penzance.

§ 2. *Pyramidal lead spar, or yellow lead spar*. Colour wax-yellow. Massive, cellular, and crystallized. Its primitive form is a pyramid, in which the angles are 99° 40′ and 131° 45′. Its secondary forms are, the pyramid variously truncated on the angles and summits, and a regular eight-sided table. Lustre resinous. Cleavage fourfold. Fracture uneven. Translucent. As hard as calcareous spar. Brittle. Sp. gr. 6.5 to 6.8.—*Mohs*. (5.706, *Hatchett*). Its constituents are, oxide of lead 58.4, molybdic acid 38, oxide of iron 2.08, silica 0.28.—*Hatchett*. It occurs at Bleiberg in Carinthia.

§ 3. *Prismatic lead spar*, or *red lead spar*. Colour hyacinth-red. Crystallized, in long slightly oblique four-sided prisms, variously bevelled, acuminated, or truncated. Splendent, adamantine. Fracture uneven. Translucent. Streak between lemon-yellow and orange-yellow. Harder than gypsum. Sectile. Easily frangible. Sp. gr. 6.0 to 6.1. Before the blowpipe it crackles and melts into a gray slag. It does not effervesce with acids. Its constituents are, oxide of lead 63.96, chromic acid 36.4.—*Vauquelin*. It occurs in veins in gneiss in the gold mines of Beresofsk in Siberia.

§ 4. *Rhomboidal lead spar*.

a. Green lead spar. Colour grass-green. Imitative or crystallized. The primitive form is a dirhomboid, or a flat equiangular double six-sided pyramid. The secondary forms are, the equiangular six-sided prism, variously truncated and acuminated. Splendent. Fracture uneven. Translucent. Sometimes as hard as fluor. Brittle. Sp. gr. 6.9 to 7.2. It dissolves in acids without effervescence. Its constituents are, oxide of lead 80, phosphoric acid 18, muriatic acid 1.62, oxide of iron, a trace.—*Klaproth.* It occurs along with galena at Leadhills, and Wanlockhead; at Alston in Cumberland, &c.

b. Brown lead spar. Colour clove-brown. Massive and crystallized; in an equiangular six-sided prism; and an acute double three-sided pyramid. Glistening, resinous. Feebly translucent. Streak grayish-white. Brittle. Sp. gr. 6.91. It melts before the blowpipe, and, during cooling, shoots into acicular crystals. It dissolves without effervescence in nitric acid. Its constituents are, oxide of lead 78.58, phosphoric acid 19.73, muriatic acid 1.65. It occurs in veins that traverse gneiss. It is found at Miess in Bohemia.

§ 5. *Diprismatic lead spar.*

a. White lead spar. Carbonate of lead. Colour white. Massive and crystallized; in a very oblique four-sided prism; an unequiangular six-sided prism; acute double six-sided pyramid; oblique double four-sided pyramid; long acicular crystals; and in twin and triple crystals. Lustre adamantine. Fracture small conchoidal. Translucent.. Refracts double in a high degree. Harder than calcareous spar. Brittle. Sp. gr. 6.2 to 6.6. It dissolves with effervescence in muriatic and nitric acids. It yields a metallic globule with the blowpipe. Its constituents are, oxide of lead 82, carbonic acid 16, water 2.—*Klaproth.* It occurs in veins at Leadhills in Lanarkshire.

b. Black lead spar. Colour grayish-black. Massive, cellular, and seldom crystallized, in very small six-sided prisms. Splendent, metallo-adamantine. Fracture uneven. Streak whitish-gray. Its constituents are, oxide of lead 79, carbonic acid 18, carbon 2.—*Lampadius.* It occurs in the upper part of veins, at Leadhills, &c.

c. Earthy lead spar. Colour yellowish-gray. Massive. Glimmering. Opaque. Streak brown. Very soft. Sp. gr. 5.579. Its constituents are, oxide of lead 66, carbonic acid 12, water 2.25, silica 10.5, alumina 4.75, iron and oxide of manganese 2.25.—*John.* It is found at Wanlockhead.

Corneous lead ore, or *muriate of lead.* Colour grayish-white. Crystallized, in an oblique four-sided prism, variously truncated, bevelled, and acuminated. Splendent and adamantine. Cleavage threefold. Fracture conchoidal. Transparent. Soft. Sectile, and easily frangible. Sp. gr. 6.065. It melts into an orange-coloured globule. Its constituents are, oxide of lead 85.5, muriatic acid 8.5, carbonic acid 6.—*Klaproth.* It is found in Cromford-level near Matlock in Derbyshire.

Arseniate of lead.

§ 1. *Reniform.* Colour reddish-brown. Shining. Fracture conchoidal. Opaque. Soft and brittle. Sp. gr. 3.933. It gives out arsenical vapours with the blowpipe. It colours glass of borax lemon-yellow. Its constituents are, oxide of lead 35, arsenic acid 25, water 10, oxide of iron 14, silver 1.15, silica 7, alumina 2. It is found in Siberia.

§ 2. *Filamentous.* Colours green or yellow. In acicular six-sided prisms, or in silky fibres. Slightly flexible and easily frangible. Sp. gr. 5.0 to 6.4. Its constituents are, oxide of lead 69.76, arsenic acid 26.4, muriatic acid 1.58.—*Gregor.* It occurs in Cornwall.

§ 3. *Earthy arseniate.* Colour yellow. In crusts. Friable. It occurs at St. Prix in France.

Native minium. Colour scarlet-red. Massive, amorphous, and pulverulent. It is found in Grassington-moor, Craven. Mr. Smithson thinks this mineral is produced by the decay of galena or lead-glance.

XI. MANGANESE ORES.

1. *Prismatic manganese ore.*

§ 1. *Gray manganese ore.*

a. Fibrous gray manganese ore. Colour dark steel-gray. Massive, imitative, and in very delicate acicular crystals, and in thin and long rectangular four-sided tables. Shining and splendent. Soils strongly. Soft. Brittle. It occurs in the Westerwald.

b. Radiated. Colour dark steel-gray. Massive, imitative, and crystallized. The primitive form is an oblique four-sided prism, in which the largest angle is about 100°. Secondary forms are, the primitive bevelled, or acuminated, or spicular crystals. Cleavage prismatic. Streak dull black. Soils. Soft. Brittle. Sp. gr. 4.4 to 4.8. Shining and metallic. Its constituents are, black oxide of manganese 90.5, oxygen 2.25, water 7.—*Klaproth.* It occurs in the vicinity of Aberdeen, in Cornwall, Devonshire, &c.

c. Foliated. Colour between steel-gray and iron-black. Massive and crystallized in short oblique four-sided prisms. Shining, metallic. Cleavage prismatic. Fracture uneven. Other characters, as above. Sp. gr. 3.742. It is found in Devonshire.

d. Compact. Fracture even, or flat conchoidal. Sp. gr. 4 to 4.4. Other characters as preceding. Its constituents are, yellow oxide of manganese 50? oxygen 33, barytes 14, silica 1 to 6. *Analysis doubtful.* It occurs at Upton Pyne in Devonshire.

e. Earthy. Friable. It consists of semimetallic feebly glimmering fine scaly particles, which soil strongly. It occurs in the mine Johannis in the Erzegebirge. It tinges borax purple; and effervesces with muriatic acid, giving out chlorine. These five kinds occur in granite, gneiss, &c. either in veins or in large cotemporaneous masses.

§ 2. *Black manganese ore.*

a. Compact. Colour between bluish-black and steel-gray. Massive, imitative, and in curved lamellar concretions. Glimmering and imperfect metallic lustre. Fracture conchoidal. Streak shining, with colour unchanged. Semihard. Brittle. Sp. gr. 4.75.

b. Fibrous. Massive, imitative, and in delicate scopiform concretions. Fragments cuneiform and splintery. Its other characters as above. It yields a violet-blue glass with borax. It occurs in veins in the Erzegebirge. It yields a good iron; but acts very powerfully on the sides of the furnace. It is called black hematite.

c. Foliated. Colour brownish-black. Crystallized sometimes in acute double four-sided pyramids. Shining. Cleavage single, and curved foliated. Streak dark reddish-brown. Brittle. It is supposed to consist of iron and manganese.

§ 3. *Scaly brown manganese ore.* Colour between steel-gray and clove-brown. In crusts. Massive and imitative. Friable. Composed of shining scaly particles. Soils strongly. Feels greasy. It gives to glass of borax an olive-green colour. It occurs in drusy cavities in brown hematite. It is found near Sandlodge in Mainland, one of the Shetlands.

4. *Manganese blende.*

Prismatic. Colour iron-black. Massive, in distinct concretions, and sometimes crystallized. Primitive form, an oblique four-sided prism, which becomes variously modified by truncations on the lateral edges. Lustre splendent, and semi-metallic. Streak greenish. Harder than calcareous spar. Easily frangible. Before the blowpipe it gives out sulphur, and tinges borax violet-blue. Its constituents are, oxide of manganese 82, sulphur 11.5, carbonic acid 5.—*Klaproth.* Oxide of manganese 85, sulphur 15.—*Vauquelin.* It is found in Cornwall.

5. *Phosphate of manganese.* Colour brownish-black. Massive and disseminated. Glistening. Fracture flat conchoidal. Semi-transparent, in splinters. Scratches glass. Streak yellowish-gray. Brittle. Sp. gr. 3.5 to 3.7. It is fusible into a black enamel. Its constituents are, oxide of manganese 42, oxide of iron 31, phosphoric acid 27. It occurs in a coarse granular granite at Limoges in France.

6. *Rhomboidal red manganese.*

a. Foliated. Colour bright rose-red. Massive, imitative, and crystallized in rhomboids. Shining, pearly. Cleavage rhomboidal. Translucent on the edges. Hardness between fluor and calcareous spar. Brittle. Sp. gr. 3.3 to 3.6. Before the blowpipe it first becomes dark brown, and then melts into a reddish-brown bead. Its constituents are, oxide of manganese 52.6, silica 39.6, oxide of iron 4.6, lime 1.5, volatile ingredients 2.75.—*Berzelius.* It occurs in beds of specular iron ore in gneiss hills in Sweden and Siberia. The specimens of the latter are cut into ornamental stones.

b. Fibrous. Colours, rose-red and flesh-red. Massive and in distinct prismatic fibrous concretions. Glistening and pearly. Fragments splintery. Feebly translucent. It occurs in Transylvania and Hungary.

c. Compact. Colour pale rose-red. Massive or reniform. Glimmering. Sp. gr. 3.3 to 3.9. Its constituents are, oxide of manganese 61, silica 30, oxide of iron 5, alumina 2.—*Lampad.* It occurs at Kapnik in Transylvania.

Pitchy iron ore may be regarded as a phosphate of manganese.

XII. MERCURY ORES.

1. *Native mercury.*

a. Fluid mercury. See MERCURY. It occurs principally in rocks of the coal formation, associated with cinnabar, corneous mercury, &c. Small veins of it are rarely met with in primitive rocks, accompanied with native silver, &c. It is found at Idria in the Friaul; Niderslana in Upper Hungary; in the Palatinate; Deux-Ponts, &c.

b. Dodecahedral mercury, or *native amalgam.*

§ 1. *Fluid* or *semi-fluid amalgam.* Colour tin-white. In roundish portions; and crystallized in a rhomboidal dodecahedron, rarely perfect. Splendent. When cut it emits a creaking sound. As hard as talc. Sp. gr. 10·5. Its constituents are, mercury 74, silver 25. It is found at Deux-Ponts.

§ 2. *Solid amalgam.* Colour silver-white. Massive and disseminated. Fracture flat conchoidal. As hard as gypsum. Brittle. Creaks strongly when cut. Sp. gr. 10.5. The mercury flies off before the blowpipe. Its constituents are, mercury 74, silver 25. —*Heyer.* Mercury 64, silver 36.—*Klaproth.* It is found in Hungary, the Deux-Ponts, &c.

2. *Cinnabar*, or *prismato-rhomboidal ruby-blende.*

a. Dark red cinnabar. Colour cochineal-red. Massive, disseminated, imitative, and crystallized. Primitive form a rhomboid. Secondary forms; a regular six-sided prism, an acute rhomboid, and a six-sided table. Splendent, adamantine. Translucent. Streak scarlet-red, shining. Harder than gypsum. Sectile and easily frangible. Sp. gr. 6.7 to 8·2. It melts, and is volatilized with a blue flame and sulphureous odour. Its constituents are, mercury 84·5, sulphur 14·75.—*Klaproth.*

b. Bright red cinnabar. Colour bright scarlet-red. Massive, and in delicate fibrous concretions. Glimmering and pearly. Fracture earthy. Opaque. Streak shining. Soils. Friable. It occurs in rocks of clay-slate, talc-slate, and chlorite slate; in veins at *Horzowitz* in Bohemia; at Idria, &c.

c. Hepatic cinnabar.

§ 1. *Compact.* Colour between cochineal-red and dark lead-gray. Massive. Glimmering and semi-metallic. Streak shining.

Opaque. Soft. Sectile. Sp. gr. 7·2. Its constituents are, mercury 81·8, sulphur 13·75, carbon 2·3, silica 0·65, alumina 0.55, oxide of iron 0·2, copper 0·02, water 0·73.

§ 2. *Slaty mercurial hepatic ore.* Colour as above, but sometimes approaching to black. Massive, and in roundish concretions. Lustre shining, semi-metallic. Fracture curved slaty. Most easily frangible. Streak cochineal-red, inclining to brown. Rather lighter than the compact. It occurs in considerable masses in slate-clay and bituminous shale. It is most abundant in Idria.

3. *Corneous mercury*, or *horn quicksilver*.

Pyramidal corneous mercury. Colour ash-gray. Vesicular, with interior crystallizations, which are, a rectangular four-sided prism, variously acuminated, and a double four-sided pyramid. Crystals very minute. Shining, adamantine. Cleavage single. Faintly translucent. Soft. Sectile and easily frangible. It is totally volatilized before the blowpipe, with a garlic smell. It is soluble in water, and the solution mixed with lime-water gives an orange-coloured precipitate. Its constituents are, oxide of mercury 76, muriatic acid 16·4, sulphuric acid 7·6.—*Klaproth.*—It occurs in Bohemia, &c.

XIII. MOLYBDENA ORES.

Rhomboidal molybdena. Colour fresh lead-gray. Massive, in plates, and sometimes crystallized. Primitive form is a rhomboid. Secondary figures are, a regular six-sided table, and a very short six-sided prism, flatly acuminated on both extremities. Splendent, metallic. Cleavage single. Opaque. Streak on paper bluish-gray; on porcelain greenish-grey. Soils slightly. Harder than talc. Easily frangible. Splits easily. In thin leaves flexible, but not elastic. Sectile, approaching to malleable. Feels greasy. Sp. gr. 4·4 to 4·6. It emits a sulphureous odour before the blowpipe. It is soluble, with violent effervescence, in carbonate of soda. Its constituents are, molybdena 60, sulphur 40.—*Bucholz.* It occurs disseminated in granite, gneiss, &c. It is found in Glenelg in Inverness-shire, at Peterhead, at Corybuy at the head of Loch Creran, in Cornwall, &c.

Molybdena ochre. Colour sulphur-yellow. Disseminated and incrusting molybdena. Friable; dull. In Corybuy and Norway.

For *Molybdate of lead*, see LEAD ORES.

XIV. NICKEL ORES.

1. *Native nickel.* Colour brass-yellow. In delicate capillary crystals. Shining and metallic. Crystals rigid. Brittle. It consists, according to Klaproth, of nickel, with a small quantity of cobalt and arsenic. It occurs in veins in gneiss in Saxony.

2. *Nickel pyrites*, or *copper-nickel.*

Prismatic nickel pyrites. Colour copper-red, becoming black. Massive, disseminated, imitative, and crystallized, in oblique four-sided prisms. Shining, metallic. Harder than apatite. Rather difficultly frangible. Sp. gr. 7·5 to 7·7. It emits an arsenical vapour before the blowpipe, and then fuses into a dark scoria, mixed with metallic grains. It yields a dark green solution with nitro-muriatic acid. Its constituents are, nickel and arsenic, with accidental admixtures of cobalt, iron, and sulphur. It generally occurs in primitive rocks. It is found in small quantities at Leadhills and Wanlockhead, and in the coal field of Linlithgowshire.

Black nickel. Colour dark grayish-black. Massive, and in crusts. Dull. Earthy fracture. Soft. Streak shining. Soils slightly. It forms an apple-green coloured solution with nitric acid, which lets fall a white precipitate with arsenic acid. It occurs in veins that traverse bituminous marle-slate at Riegelsdorf.

Nickel ochre. Colour apple-green. In an efflorescence. Dull. Fracture splintery. Soft. Feels meagre. It gives to glass of borax a hyacinth-red colour. It occurs at Leadhills, at Alva in Stirlingshire, and in Saxony. It consists of oxide of nickel 67, oxide of iron 23.2, water 1.5, loss 8·3.—*Lampadius.*

XV. PALLADIUM ORE.

Native palladium. Colour pale steel-gray, passing into silver-white. It occurs in small grains. Lustre metallic. Fracture diverging fibrous. Opaque. Sp. gr. 11·8 to 12·148. It is infusible; but on the addition of sulphur it melts. It forms a deep red solution with nitric acid. It consists of palladium, alloyed with a minute portion of platina and iridium. It is found in grains along with grains of native platina, in the alluvial gold districts in Brazil.—*Wollaston.*

XVI. PLATINA ORE. Colour very light steel-gray. In flat small grains. Shining and metallic. Nearly as hard as iron. Malleable. Sp. gr. 17·7. It is found in the gray silver ore of Guadalcanal in Spain, in Choco, in New Granada, and in the province of Barbacoas. It is peculiar to an alluvial tract of 600 leagues, where it is associated with grains of native gold, zircon, spinel, quartz, and magnetic ironstone. It is not true that this metal occurs near Carthagena, or Santa Fé, or in the islands of Porto Rico and Barbadoes, or in Peru, although these different localities are mentioned by authors. The *gray copper ore* of Guadalcanal in Spain contains from 1 to 10 per cent. of platina.

XVII. SILVER ORES.

1. *Hexahedral*, or *native silver.*

a. Common native silver. Colour pure silver-white. Disseminated, in plates or membranes, imitative, and crystallized; in a cube; octohedron; tetrahedron; rhomboidal dodecahedron; leucite form; and six-sided table. Crystals microscopic. Shining and metallic. Fracture fine hackly. Streak splendent. Harder than gold, tin, lead; but softer than iron, platina, and copper. Perfectly malleable.

Flexible, and difficultly frangible. Sp. gr. 10 to 10·4. Its constituents are, metallic silver 99, metallic antimony 1, with a trace of copper and arsenic.—*John.* It occurs principally in veins in primitive mountains. In granite in the Erzegebirge. In gneiss and mica-slate in Saxony, Bohemia, and Norway. In clay-slate in Ireland. In clay porphyry at Alva, in the Ochil Hills, Stirlingshire. For a copious list of localities, see *Jameson's Mineralogy.*

b. Auriferous native silver. Colour between brass-yellow and silver-white. Disseminated in membranes, and crystallised in cubes. Its sp. gr. is greater than that of the preceding. Its constituents are, silver 72, gold 28.—*Fordyce.* It occurs in veins in primitive rocks at Kongsberg in Norway.

2. *Silver-glance,* or *vitreous silver.*

§ 1. *Hexahedral.*

a. Compact. Colour dark blackish lead-gray. Massive, imitative, and crystallized; in a cube, octohedron, rhomboidal dodecahedron, and double eight-sided pyramid. Glistening, metallic. Cleavage rhomboidal. Harder than gypsum. Completely malleable. Flexible, but not elastic. Difficultly frangible. Sp. gr. 5·7 to 6·1. Before the blowpipe it loses its sulphur, and a bead of pure silver remains. Its constituents are, silver 85, sulphur 15.—*Klaproth.* It is one of the most frequent of the ores of silver. It occurs in mica-slate, clay-slate, greywacke, and seldomer in granite. It is found in Cornwall.

b. Earthy. Colour bluish-black. In crusts. Friable or solid. Dull. Feebly translucent. Streak shining metallic. Soils a little. Easily frangible. Sectile. It is easily fused by the blowpipe. It is a sulphuret of silver.

§ 2. *Rhomboidal silver glance.* Colour between iron-black and blackish lead-gray. Crystallized. Primitive form, a rhomboid. Secondary figures; an equiangular six-sided prism, an equiangular six-sided table, and a double six-sided pyramid. The tabular crystals often intersect each other, forming cells. Highly splendent, and metallic. Soft. Sectile. Easily frangible. Sp. gr. 5·7 to 6·1. It melts with difficulty. Its constituents are, silver 66·5, sulphur 12, antimony 10, iron 5, copper and arsenic 0·5, earthy substances 1·0. It occurs in gneiss, &c. It is found in the district of Freyberg.

2. *White silver.* Colour very light lead-gray. Massive, disseminated, and always associated with lead-glance. Glistening and metallic. Fracture even. Soft. Sectile. Easily frangible. Sp. gr. 5·3 to 5·6. Before the blowpipe it melts and partly evaporates, leaving a bead of impure silver, surrounded by a yellow powder. Its constituents are, lead 41, silver 9·25, antimony 21·5, iron 1·75, sulphur 22, alumina 1, silica 0.75.—*Klaproth.* It occurs in gneiss. It is found near Freyberg.

3. *Gray silver,* or *carbonate of silver.* Colour ash-gray. Massive and disseminated. Glistening. Fracture uneven. Soft. Streak more shining. Brittle. Heavy. Easily reduced before the blowpipe. Its constituents are, silver 72·5, carbonic acid 12, oxide of antimony, and a trace of copper 15·5.—*Selb.* It occurs in veins that traverse granite in the Black Forest.

4. *Antimonial silver,* or *dodecahedral antimony.* Colour between silver-white and tin-white. Massive, disseminated, in distinct concretions, and crystallized; in a rectangular four-sided prism, in an equiangular six-sided prism, and a double six-sided pyramid, truncated on the apices. Surface of the prisms longitudinally streaked. Splendent, metallic. Cleavage octohedral. Hardness, between calc and fluor spar. Sp. gr. 9.4 to 10. The antimony is volatilized before the blowpipe, and silver remains on the charcoal. Its constituents are, silver 78, antimony 22.—*Vauquelin.* It occurs in veins in granite and greywacke. In the first, at Altwolfach in Suabia; in clay-slate in the Hartz.

5. *Arsenical silver.* Colour on the fresh surface tin-white, which tarnishes grayish-black. Massive, and reniform. Fracture small-grained uneven. Harder than antimonial silver. Streak shining. Sectile, and easily frangible. Sp. gr. 9.44. Before the blowpipe the antimony and arsenic are volatilized with a garlic smell, while a globule of silver remains, which is more or less pure. Its constituents are, arsenic 35, iron 44.25, silver 12.75, antimony 4. It generally occurs along with native arsenic. It is found in the Hartz.

6. *Bismuthic silver.* Colour pale lead-gray. Disseminated, and rarely crystallized in capillary crystals. Glistening and metallic. Soft. Sectile. Easily frangible. Its constituents are, bismuth 27, lead 33, silver 15, iron 4.3, copper 0.9, sulphur 16.3.—*Klaproth.* It has been found only in the Friedrich-Christian Mine in the Black Forest, in veins, in gneiss.

7. *Ruby-blende.*

§ 1. *Rhomboidal ruby-blende.*

a. Dark red silver. Colour between cochineal-red, and dark lead-gray. Massive, in membranes, and crystallized. Prim. form, a rhomboid of 109° 28′. Secondary forms, an equiangular six-sided prism, variously truncated and acuminated; and an equiangular double six-sided pyramid. Splendent and adamantine. Cleavage rhomboidal. Semi-transparent. Streak cochineal-red. Harder than gypsum. Sectile. Easily frangible. Sp. gr. 5.2 to 5.7. Before the blowpipe, it first decrepitates, then melts with a slight effervescence, leaving a globule of silver. Its constituents are, silver 60, antimony 20.3, sulphur 14.7, oxygen 5.—*Klaproth.* It occurs in veins in gneiss, &c. It is found in the silver mines of Kongsberg, and in those of the Hartz.

§ 2. *Light red silver.* Colour cochineal-red. Streak aurora-red, passing into cochineal-red. Sp. gr. 5·5 to 5.9. In other respects, as preceding. Its constituents are, silver 54.27, antimony 16.3, sulphur 17.75, oxygen 11.85.—*Vauquelin.* It occurs at Andreasberg in the Hartz.

XVIII. TANTALUM ORES.

1. *Prismatic tantalum ore. Columbite of Hatchett.* Colours grayish and brownish-black. Massive, disseminated, and crystallized in oblique four-sided prisms. Semi-metallic adamantine lustre. Fracture coarse-grained uneven. Opaque. As hard as felspar. Difficultly frangible. Sp. gr. 6.0 to 6.3. It does not fuse with glass of borax. Its constituents are,

	Wollaston.	
oxide of tantalum,	85	80
oxide of iron,	10	15
oxide of manganese,	4	5
	Finland.	N. American or Columbite.

It occurs in a coarse red granite in Finland, and in Massachusset's Bay, in North America.

2. *Yttrotantalite.* Colours iron-black and yellowish brown. Embedded in angular pieces, and crystallized in oblique four-sided and in six-sided prisms. Resinous, metallic lustre. Fracture conchoidal. Opaque. Scratches glass. Streak gray-coloured. Easily frangible. Sp. gr. 5.4 to 5·88. It decrepitates, but does not fuse, with the blowpipe. Its constituents are, oxide of tantalum 57, yttria 20.25, lime 6.25, oxide of iron 3.5, oxide of uranium 0.5, tungstic acid 8.25. It occurs along with gadolinite in a bed of flesh-red felspar in gneiss at Ytterby in Sweden.

XIX. TELLURIUM ORES.

1. *Hexahedral* or *native tellurium.* Colour tin-white. Massive, disseminated, and in rectangular four-sided prisms, acuminated with four planes. Shining, metallic. Cleavage hexahedral. As hard as gypsum. Rather brittle. Sp. gr. 6.1 to 6.2. It melts as easily as lead, emits a thick white smoke, and burns with a light green colour, and a pungent acrid odour, like that of horse-radish. Its constituents are, tellurium 92.55, iron 7.2, gold 0.25. It occurs in veins in graywacke, at Faceby in Transylvania, and in Norway.

2. *Prismatic black tellurium.* Colour between blackish lead-gray and iron-black. Massive, in flakes, and crystallized. Primitive figure, an oblique four-sided prism. Secondary forms are, an oblique four-sided table, a six-sided table, an eight-sided table, and an acute double four-sided pyramid. Splendent and metallic. Fragments tabular. Harder than talc. Sectile. Soils slightly. The thin leaves and tables are flexible. Sp. gr. 7.0 to 7.2. It melts very easily before the blowpipe. Its constituents are, tellurium 32.2, lead 54, gold 9, sulphur 3, copper 1.3, silver 0.5.—*Klaproth.* It is worked for the gold it contains. It is found at Naygag in Transylvania.

3. *Prismatic gold glance.*

§ 1. *Graphic gold glance*, or *tellurium.* Colour steel-gray. Massive, in leaves and crystallized. Primitive form, an oblique four-sided prism. Splendent, metallic. Cleavage prismatic. Fracture fine-grained uneven. As hard as gypsum. Brittle. Soils slightly. Sp. gr. 5.7 to 5.8. Before the blowpipe it burns with a green flame, and is volatilized. Its constituents are, tellurium 60, gold 30, silver 10. It occurs in porphyry in Transylvania.

§ 2. *Yellow gold glance*, or *yellow tellurium.* Colour silver-white, inclining to brass-yellow. Disseminated and crystallized, in four-sided acicular prisms, which are rare. Splendent, metallic. Cleavage prismatic. Fracture small-grained uneven. Sp. gr. 5.7 to 5.8. Its constituents are, tellurium 44.75, gold 26.75, lead 19.5, silver 8.5, sulphur 0.5. —*Klaproth.* It occurs in veins in porphyry at Naygag in Transylvania.

XX. TIN ORES.

1. *Pyramidal tin ore.*

§ 1. *Common tin ore*, or *tinstone.* Colour blackish-brown. Massive, disseminated, but most frequently crystallized. Primitive form, a double four-sided pyramid, in which the angles are 133° 36′ and 67° 42′. Secondary figures are, the primitive truncated; a rectangular four-sided prism, variously truncated or acuminated, and twin crystals. Splendent, and adamantine. Fracture uneven. From semitransparent to opaque. Streak grayish-white. As hard as felspar, somtimes as quartz. Easily frangible. Sp. gr. 6.3 to 7.0. Before the blowpipe it decrepitates, and becomes paler, and is reduced to the metallic state. Its constituents are, tin 77.5, iron 0.25, oxygen 21.5, silica 0.75. It occurs in granite, gneiss, &c.; and in an alluvial form, in what are in Cornwall called *stream works.* There are only three tin districts in Europe: Cornwall, which is the most considerable; the Erzegebirge; and Monte Rey, in Gallicia.

§ 2. *Cornish tin ore*, or *wood-tin.* Colour hair-brown. In rolled and imitative shapes. Glistening. Opaque. Softer than common tinstone. Streak gray, inclining to brown. Brittle. Sp. gr. 6.4. Its constituents are, oxide of tin 91, oxide of iron 9.—*Vauquelin.* It occurs along with stream-tin.

2. *Tin pyrites.* Colour between steel-gray and brass-yellow. Massive and disseminated. Glistening and metallic. Fracture uneven. Yields easily to the knife. Brittle. Sp. gr. 4.35. Not magnetic. Before the blowpipe it exhales a sulphureous vapour, and melts easily. Its constituents are, tin 34, copper 36, iron 3, sulphur 25, earthy matter 2.—*Klaproth.* It has been found only in Cornwall, in granite, at St. Michael's Mount.

XXI. TITANIUM ORES.

1. *Prismatic titanium ore*, or *sphene*.

a. Common sphene. Colours, reddish, yellowish, and reddish-brown. It occurs in granular concretions, and crystallized in the following forms: A low very oblique four-sided prism, bevelled or truncated; a broad six-sided prism; a rectangular four-sided prism; an oblique double four-sided pyramid. Shining and adamantine. Fracture imperfect conchoidal. Streak grayish or yellowish-white. Harder than apatite. Brittle. Sp. gr. 3.4 to 3.6. Before the blowpipe it is fusible with difficulty into a brownish-black enamel. Its constituents are, oxide of titanium 46, silica 36, lime 16, water 1.—*Klaproth*. It occurs in the syenite of Criffle, and other hills in Galloway; in the syenite of Inverary; on the south side of Loch-Ness; the granite of Aberdeen; the syenite of Culloden, in Inverness-shire; in the floetz rocks of Mid-Lothian; and at Arendal, in Norway.

b. Foliated sphene. Colour yellow. Massive, in straight lamellar concretions, and crystallized as the preceding. Lustre splendent. Cleavage double. Fracture imperfect conchoidal. Translucent. It occurs at La Portia, in Piedmont, St. Gothard, and Arendal.

2. *Prismato-pyramidal titanium ore*.

a. Rutile. Colour reddish-brown. Massive and crystallized. Primitive figure, a pyramid of 117° 2′ and 84° 48′. Secondary forms are, a long rectangular four-sided prism; four-sided prism; six-sided prism; and acicular crystals. The crystals are occasionally curved. Splendent or glistening. Streak brown. Translucent. Harder than apatite. Brittle. Sp. gr. 4.255.—*Lowry*. It is pure oxide of titanium, with a little oxide of iron. It occurs in the granite of Cairngorm, the limestone of Rannoch, and in the rocks of Ben Gloe, where it was discovered by Dr. M'Culloch.

b. Iserine. Colour iron-black. In obtuse angular grains, and in rolled pieces. Splendent and metallic. Fracture conchoidal. Harder than felspar. Opaque. Brittle. Sp. gr. 4.6. Before the blowpipe it melts into a blackish-brown coloured glass, which is slightly attracted by the magnet. Its constituents are, oxide of titanium 28, oxide of iron 72.—*Klaproth*; or, oxide of titanium 48, oxide of iron 48, oxide of uranium 2.—*Thomson*. It occurs embedded in gneiss, and disseminated in granite sand, along with iron-sand, in the bed of the river Don, in Aberdeenshire.

c. Menachanite. Colour grayish-black. In small flattish angular grains. Glimmering or semi-metallic. Opaque. Brittle. Sp. gr. 4.427. It is attractible by the magnet. Its constituents are, oxide of iron 51, oxide of titanium 45.25, oxide of manganese 0.25, silica 3.5.—*Klaproth*. It is found in the valley of Manaccan in Cornwall.

3. *Pyramidal titanium ore*, or *octohedrite*. Colour passes from indigo-blue to brown. Crystallized. Its primitive form is a pyramid of 97° 38′ and 137° 10′. The following are secondary figures; the pyramid truncated on the extremities, and double four-sided pyramid variously acuminated. Lustre splendent, adamantine. Cleavage fourfold. Translucent. Harder than apatite. Brittle. Sp. gr. 3·8 to 3·9. It is oxide of titanium. It is found in Dauphiny.

XXII. TUNGSTEN ORES.

1. *Pyramidal tungsten*, or *scheelium*. Colour white. Massive, and sometimes crystallized. The primitive form is a rather acute double four-sided pyramid. Secondary forms are, the primitive figure bevelled on the angles; a very acute double four-sided pyramid: a flat double four-sided pyramid; a square lenticular figure; and a flat double four-sided pyramid. Shining. Fracture uneven. Cleavage ninefold. Translucent. Harder than fluor spar. Brittle. Sp. gr. 6 to 6·1. Its constituents are, oxide of tungsten 65, lime 31, silica 4.—*Scheele*; oxide of tungsten 75·25, lime 18·70, silica 1·56, oxide of iron 1·25, oxide of manganese 0·75.—*Klaproth*. It occurs along with tin-stone and wolfram, in Cornwall; in Sweden; Saxony, &c.

2. *Wolfram*.

Prismatic wolfram. Colour black. Massive and crystallized. Primitive form is an oblique four-sided prism of 120°. Secondary forms are, the oblique four-sided prism, bevelled, truncated, or acuminated; and a twin crystal. Shining. Fracture uneven. Opaque. Streak dark reddish-brown. Harder than apatite. Brittle. Sp. gr. 7·1 to 7·4. Its constituents are, tungstic acid 67, oxide of manganese 6·25, oxide of iron 18·10, silica 1·5.—*Vauquelin*. It occurs in gneiss in the island of Rona of the Hebrides, and in Cornwall.

XXIII. URANIUM ORES.

1. *Uran ochre*.

a. Friable. Colour lemon-yellow. It occurs as a coating on pitch ore. It is composed of dull, weakly cohering particles. It feels meagre.

b. Indurated. Colour straw-yellow. Massive and superimposed. Glimmering. Opaque. Soft. Sp. gr. 3·15. The yellow varieties are pure oxide of uranium. The brownish and reddish contain a little iron. It is found in Bohemia and Saxony.

2. *Indivisible uranium* or *pitch ore*. Colour greenish-black. Massive, reniform, and in distinct concretions. Shining. Hardness between apatite and felspar. Opaque. Brittle. Sp. gr. 6·4 to 6·6. Its constituents are, oxide of uranium 86·5, black oxide of iron 2·5, galena 6·0, silica 5.—*Klaproth*. It occurs in primitive rocks. It is found in Cornwall.

3. *Uranite* or *uran mica*.

Pyramidal uran mica. Colour grass-green. In flakes and crystallized. Primitive form, a pyramid, in which the angles are 95° 13′ and 144° 56′. The secondary forms are, a rectangular four-sided table or short prism, and a four-sided table variously bevelled and truncated. Shining. Cleavage fourfold and rectangular. Transparent and translucent. Scratches gypsum, but not calcareous spar. Streak green. Sectile. Not flexible. Easily frangible. Sp. gr. 3·1 to 3·2. It decrepitates violently before the blowpipe on charcoal; loses about 33 per cent. by ignition, and acquires a brass-yellow colour. Its constituents are, oxide of uranium, with a trace of oxide of lead 74·4, oxide of copper 8·2, water 15·4.—*Gregor.* It occurs in veins in primitive rocks. It is found in Cornwall and Saxony.

XXIV. WOODANIUM ORES?

Woodan pyrites. Colour dark tin-white. In vesicular massive portions. Lustre shining and metallic. Fracture uneven. Opaque. Harder than fluor, but softer than apatite. Brittle. Sp. gr. 5·192. It was said to contain 20 per cent. of wodanium, combined with sulphur, arsenic, iron, and nickel. It occurs at Topschau in Hungary.

XXV. ZINC ORES.

1. *Red zinc, or red oxide of zinc.* Colour blood-red. Massive, disseminated. On the fresh fracture, shining. Cleavage single. Fracture conchoidal. Translucent on the edges. Easily scratched by the knife. Brittle. Streak brownish-yellow. Sp. gr. 6·22. It is soluble in the mineral acids. Its constituents are, zinc 76, oxygen 16, oxides of manganese and iron 8.—*Bruce.* It has been found in New Jersey, North America.

2. *Zinc blende.*

Dodecahedral zinc blende.

a. Yellow. Wax-yellow, and several other colours, inclining to green. Massive, disseminated, and crystallized in octohedrons, rhomboidal dodecahedrons, and twin crystals. Splendent and adamantine. Cleavage dodecahedral, or sixfold. Translucent. Refracts single. Streak yellowish-gray. Harder than calcareous spar. Brittle. Sp. gr. 4 to 4·2. It becomes phosphorescent by friction. Its constituents are, zinc 64, sulphur 20, iron 5, fluoric acid 4, silica 1, water 6.—*Bergmann.* It occurs in veins, associated with galena. It is found at Clifton mine, near Tyndrum, in Perthshire, also in Flintshire. Fine specimens are found in Bohemia.

b. Brown zinc blende.

§ 1. *Foliated.* Colour reddish-brown. Massive, disseminated, and crystallized, in a rhomboidal dodecahedron, an octohedron, a tetrahedron, and acicular crystals. Lustre between pearly and adamantine. Cleavage sixfold or tessular. Translucent. Streak yellowish-brown. Sp. gr. 4·048. Its constituents are, zinc 58·8, sulphur 23·5, iron 8·4, silica 7·0.—*Dr. Thomson.* It occurs in veins and beds, in primitive and transition rocks. It is found in the Clifton lead mine, near Tyndrum; at Cumberhead in Lanarkshire; at Leadhills; and in all the lead mines in England and Wales.

§ 2. *Fibrous.* Colour dark reddish-brown. Massive, reniform, and in radiated concretions. Glistening, inclining to pearly. Opaque. Its constituents are, zinc 62, iron 3, lead 5, arsenic 1, sulphur 21, alumina 2, water 4. It occurs in Huel-Unity copper-mine in Cornwall.

c. Black zinc blende. Colour between grayish and velvet-black. Massive, disseminated, and crystallized in the same figures as brown blende. Shining, adamantine. Opaque. The blood-red variety is translucent on the edges and angles. Streak dark yellowish-brown. Sp. gr. 4·1665. Its constituents are, oxide of zinc 53, iron 12, arsenic 5, sulphur 26, water 4. The black blende from Naygag, besides zinc, iron, and manganese, contains a portion of auriferous silver. It occurs in veins of gneiss, in Sweden, Saxony, &c.

OF THE ANALYSIS AND REDUCTION OF ORES.

By consulting the table of metallic precipitants, and studying the peculiar habitudes of the individual metals and earths, the reader may acquire a knowledge of the methods of separating them from one another, and determining the proportion of each. The limits of the present work permit me to offer merely a short account of the best modes of analyzing a few of the principal ores on the small scale, and of reducing them on the large.

I. ANTIMONY.

1. *Native antimony* was skilfully examined by Klaproth, the parent of accurate analysis, as follows: On 100 grains of the pulverized mineral he poured strong nitric acid, which attacked it with vehemence, converting it into an oxide; which being precipitable by water, he diluted the solution with this liquid, and then filtered. The clear liquid was treated with muriatic acid, which threw down the silver present, in the state of muriate, equivalent to 1 grain of the precious metal. Prussiate of potash then indicated ¼ of a grain of iron. The oxide of antimony was now dissolved in muriatic acid, the solution diluted with water, and a piece of zinc being introduced, precipitated 98 grains of metallic antimony. Hence the 100 grains of native antimony from Andreasberg, consisted of metallic

antimony, . . .	98
silver, . .	1
iron, . .	0·25
	99·25

2. *Fibrous red antimonial ore.* Klaproth digested 100 grains with muriatic acid, mixed with a few drops of nitrous, in a long-necked matrass. There was a gray residuum of 1¼ grains of sulphur. "The antimony contained

in the solution was precipitated in the state of a white oxide, by diluting it with water, and the small portion of the metal still remaining in that fluid was afterwards entirely thrown down by means of potash. The oxide thus procured was redissolved in muriatic acid, the solution diluted with six times its quantity of water, and once more combined with such a proportion of the same solvent, as was necessary in order to redissolve entirely that portion of the oxide which the affused water had precipitated. After the dilute solution had, in this manner, again been rendered clear, its ingredient antimony was reproduced as metallic antimony, by immersing polished iron in the liquor. It weighed, when collected, edulcorated, and dried, 67½ grains.—*Klaproth's Analytical Essays*, vol. ii. p. 143. *English Translation.* From the above result, and Thenard's statement of the constitution of the oxide, Klaproth inferred, that the mineral consisted of

Metallic antimony,	67·5
Oxygen, . .	10·8
Sulphur, . .	19·7
	98·0

3. If the pulverized sulphuret of antimony be acted on by nitric acid, with heat, and water be afterwards added, a precipitate will fall, consisting of oxide of antimony, with sulphur and sulphate of lead. Sulphate of silver being very soluble in dilute nitric acid, will remain in the liquid. Muriate of soda will throw down the silver, without affecting the lead, if the solution be hot and somewhat dilute. The lead, if any remain, may then be precipitated by sulphate of soda in equivalent quantity, or by hydrosulphuret of ammonia: by muriate of barytes, the sulphuric acid resulting from acidification of the sulphur may be ascertained; and by ferroprussiate of potash, the iron. On the first precipitate obtained by affusion of water, if muriatic acid be digested, the oxide of antimony will be taken up, and may be recovered in the metallic state, by immersing a piece of zinc or iron in the muriatic solution. *Lastly*, the sulphur may be separated from the sulphate of lead by ustulation.

Metallic antimony is best obtained from the sulphuret, by igniting it, after careful ustulation, with half its weight of crude tartar. The metal will be found at the bottom of the crucible. Or the ustulated oxide, mixed with oil, fat, and pounded charcoal, is to be ignited till drops of the metal begin to appear; and nitre equal to 1-16th of the weight of the oxide is then to be gradually injected. Or we form the martial regulus of antimony (antimony containing a little iron and sulphur), by adding 16 ounces of the sulphuret to six ounces of iron nails, ignited to whiteness in a crucible. When the whole are in fusion, inject gradually two ounces of pulverized nitre; then cover the crucible, and urge the heat for a little. Seven or eight ounces of the regulus will be found at the bottom. By repeating the fusion, and projection of nitre, two or three times, the regulus may be brought nearer to the state of pure metal.

In what follows, I shall confine myself to the detail of a few ingenious and exact analyses.

2. Bismuth Ores.

The following analysis of a complex metallic mineral by Klaproth, is peculiarly instructive.

Examination in the humid way of the bismuthic silver ore from Schaupbach, in the Black Forest, in Suabia.

(*a.*) Upon 300 grains of this ore he poured three ounces of nitric acid, diluted with one ounce of water. The residuum being acted on with more acid, both solutions were mixed, and evaporated to a small volume; during which process there separated from the fluid some crystalline grains, consisting of nitrate of lead.

(*b.*) The concentrated solution had a greenish colour. When afterwards diluted with just as much water as was requisite to redissolve that crystalline sediment, it was poured into a large quantity of water. This last immediately acquired a milky appearance in a high degree, and deposited a white precipitate, which weighed 44¼ grains, when collected, lixiviated, and dried in the air, and proved, on further examination, to be oxide of bismuth.

(*c.*) Into the liquor that had been freed from this oxide, and was entirely clear and colourless, he then dropped muriatic acid as long as it was rendered turbid by it. The precipitate, which now fell, did not appear to be mere muriate of silver; for this reason he digested it for some time with a moderately strong nitric acid. A considerable portion of it was thus redissolved, and left pure horn-silver behind: which, upon careful collection, and desiccation in a brisk heat, weighed 46 grains. Thus, the portion of pure silver is determined at 34½ grains.

(*d.*) The nitric acid that had been affused upon the precipitate obtained by the muriatic (*c.*), yielded by dilution with much water, 32 grains more of oxidized bismuth; which, with the preceding 44¼ (*b.*), gave together 76¼ grains. In order to ascertain the proportion of reguline bismuth in this ore, he dissolved 100 grains of bismuth in nitric acid; and, after having concentrated the solution by evaporation, he poured it into a large quantity of water. When, of the precipitate thus produced, nothing more would fall down, on adding more water he collected it on the filter, washed it, and suffered it to dry perfectly in the air. It then weighed 88 grains. To the water which had been separated from it, muriatic acid was added by drops; whereby a new precipitate ensued, weighing 32 grains, after edulcoration and drying.

As, by the result of this comparative experiment, 100 grains of bismuth have, upon the whole, given 123 grains of oxide, it follows, that the 76½ grains of oxide (*d*.) obtained from 300 grains of this ore, contain 62½ grains of metallic bismuth.

(*c*.) The remainder of the fluid was further reduced by evaporation; and in this process muriate of lead separated from it in delicate broad striated crystals. This liquor was then combined with such a quantity of sulphuric acid as was requisite to redissolve those crystals, and a second time evaporated to a consistence of pap. The precipitate which thence ensued was sulphate of lead, weighing 19 grains, when duly collected, washed, and dried.

(*f*.) What still remained of the solution, after its having been freed from the lead before contained in it, was saturated with caustic ammonia added in excess. In this way, a brown ferruginous precipitate was produced; which was rapidly attracted by the magnet, and weighed 14 grains, when, after previous desiccation, it had been moistened with linseed oil, and well ignited. For these we must reckon 10 grains of metallic iron.

(*g*.) The liquor which had been supersaturated with ammonia, and which, by its blue colour, showed that it held copper in solution, was saturated to excess with sulphuric acid. On immersing then a piece of polished iron into it, two grains of *copper* were deposited.

(*h*.) The gray residue of the ore that was left behind by the nitric acid (*a*.), weighed 178 grains. But when its sulphureous part had been deflagrated, in a crucible gently heated, it weighed only 140½ grains. This determines the portion of sulphur at 37½ grains.

(*i*.) These 140½ grains were digested with three ounces of muriatic acid, in a heat of ebullition; and the process was repeated once more with 1½ ounce of the same acid. These solutions, by means of evaporation, yielded till the end muriate of lead in tender spicular, and likewise in broad striated, crystals; which, when again dissolved in the requisite quantity of boiling water, then combined with sulphuric acid, and evaporated, yielded 89 grains of sulphate of lead. Thus, the whole quantity of this sulphate, including the 19 grains mentioned at (*e*.) amounted to 188 grains; for which, according to comparative experiments, 76 grains of reguline lead must be put in the computation.

(*k*.) That portion of the ore examined, which still remained after all the constituent parts before mentioned had been discovered, consisted merely of the *gray quartzose matrix*; the weight of which, in the ignited state, amounted to 70 grains.

Therefore, these 300 grains of bismuthic silver ore decomposed into

			Exclu.of matt.
Lead,	(*i*)	76·00	33·00
Bismuth,	(*d*)	62·20	27·00
Silver,	(*c*)	34·50	15·00
Iron,	(*f*)	10·00	4·30
Copper,	(*g*)	2·00	0·90
Sulphur,	(*h*)	37·50	16·30
Quartzose matrix,	(*k*)	70·00	
		292·20	96·5

3. *Analysis of* CERITE *by Vauquelin*:—The specimen was of a slight rose colour; and sufficiently hard to scratch glass. Sp. gr. 4.53. Streak grayish. It reddened with calcination, losing 12 per cent.

(*a*.) 100 grains of this mineral, in fine powder, were mixed with ten times their weight of nitro-muriatic acid, and subjected to ebullition for an hour: the mixture being diluted with water, and filtered, left on the filter a brown dust, which was dried and fused with caustic potash. The mixture being diluted with water, and then dissolved in muriatic acid, evaporated to dryness, and redissolved in water, left a powder which, when collected on a filter, washed and calcined, weighed 17 parts: it was pure silex, still slightly coloured yellow.

(*b*.) The nitro-muriatic solution being evaporated to dryness, and its residuum redissolved in water, left about one part of silex, coloured by a little oxide of cerium.

(*c*.) The same solution, freed from silex, and united to the washings of the silex, was decomposed by ammonia; the oxide of cerium and the oxide of iron, precipitated by this means, were separated from the liquid by filtration. The oxalic acid added to this liquid, formed a precipitate, which by calcination gave two parts of lime.

(*d*.) The metallic oxides, united and calcined, weighed 70 parts; they had a beautiful reddish-brown colour. To separate the iron from the cerium, the whole was dissolved in muriatic acid: the solution being concentrated to evaporate the excess of acid, then diluted with water, and decomposed by tartrate of potash, there was formed a very abundant white precipitate, which being washed till it contained no more foreign salts, then dried and calcined, gave 67 parts of oxide of cerium.

(*e*.) The water from the washing of the tartrate of cerium being united and mixed with hydrosulphuret of potash, gave a precipitate which became black in the air. It was oxide of iron, the weight of which, after calcination, was two parts.

Thus, 100 parts of cerite furnished by this analysis,

Silica, (*a*) (*b*), - - - - -	17
Lime (*c*), - - - - - -	2
Oxide of iron (*d*), - - - -	2
Oxide of cerium (*e*), - -	67
Water and carbonic acid, by estimate,	12
	100

4. Copper Ores. Analysis of Siberian malachite, by Klaproth:—

(*a.*) 100 grains of malachite reduced to powder, by trituration, were dissolved in nitric acid; which was effected without leaving any residue. The solution had a bright blue colour, and was saturated to excess with ammonia: but the precipitate produced was entirely and without tardiness redissolved by the excess of the alkali. This showed that the malachite here examined was perfectly free from iron, and similar admixtures.

(*b.*) He combined 100 grains of triturated malachite, with a sufficient quantity of sulphuric acid, previously diluted with five parts of water, and accurately weighed together with the vessel. After the malachites had been wholly dissolved, which was effected gradually, and with a moderately strong effervescence, the loss of weight occasioned by the carbonic acid gas that was extricated, was found to consist of 18 gr.

(*c.*) 100 grains of the same powdered malachites were ignited at a moderate heat in a covered crucible. The black residue had lost 29½ grains in weight. If from these be subtracted 18 grains for the carbonic acid, the remaining 11½ grains of loss will consist of water.

(*d.*) And lastly, 100 grains, which had been dissolved in dilute sulphuric acid, and precipitated by zinc, yielded 58 grains of pure copper.

In consequence of these experiments, the Siberian malachites consist of

Copper,	58
Carbonic acid,	18
Oxygen,	12·5
Water,	11·5
	100·0

5. Gold Ores. A very instructive analysis of the Transylvanian auriferous lamellar ore, from Naygag, by Klaproth:—

(*a.*) 1000 grains, freed in the best possible manner from the stony matrix, were triturated, and digested at a moderate heat, first with ten ounces of muriatic acid, to which nitric acid was gradually added. A violent action then took place, and the black colour of the powdered ore rapidly disappeared. While the fluid was yet hot, it was poured upon a filter; and the residue was once more digested with five ounces of muriatic acid, and the whole filtered. In a short time acicular crystals were deposited in the solution, which was yellow, and likewise on the filtering paper. These crystals were covered with boiling hot water, till they were all dissolved; after which only the quartzose portion of the matrix and some sulphur remained.

(*b.*) The sulphurous ingredient in the ore had united into a coherent mass, and could therefore be easily removed from the earthy residue. Its weight was 17½ grains. Burned on a moderately heated calcining test, it left 3½ grains of blackish residuum, which was dissolved in muriatic acid, and added to the foregoing solution. Hence the quantity of sulphur was 14 grains.

(*c.*) That portion of the matrix which consisted of white grains of quartz, weighed in the dry state 440½ grains. This being mixed with four times its quantity of carbonate of potash, was melted to vitrifaction. On breaking the crucible, a few globules of silver were found dispersed; which, however, could not be well collected. But from another experiment, to be mentioned in the sequel, it resulted, that this *silver* may be estimated at 2½ grains. Whence, since in the present case it was in the state of muriate, 3½ grains are to be subtracted, so that of the above stated weight 437 grains remain.

(*d.*) The solution (*a.*), from which, on addition of the edulcorating water, a white telluric oxide fell down in a great quantity, was concentrated by evaporation; during which process that precipitate again entirely dissolved. On the other hand, numerous crystals of muriate of lead were deposited from the liquor, even while warm; which being taken out, the evaporation was carried on as long as any more of them appeared. These crystals, when collected, were carefully rinsed by dropping upon them muriatic acid, and highly dried. They weighed 330 grains, equivalent to 248 grains of lead in the metallic state.

(*e.*) After the concentrated solution had been thus freed from lead, he diluted it a little with water, and added a large quantity of spirit of wine, as long as any white precipitate fell. The mixture having stood for a while in a gentle warmth, what precipitated was collected on the filter, edulcorated with ardent spirit, redissolved in muriatic acid, and precipitated again in the state of a pure telluric oxide by means of caustic soda, and by strictly watching the precise point of saturation. This oxide, washed and dried, gave in the balance 178 grains, which correspond to 148 grains of reguline tellurium.

(*f.*) For the purpose of ascertaining the proportion of gold, he now reduced the fluid from which the tellurium had been separated, by distilling off the spirit of wine in a retort; diluted again the concentrated solution with water; and lastly, dropped into it a nitric solution of mercury, prepared without the assistance of heat; adding this nitrate until no brown precipitate any longer appeared, and till the white precipitate which succeeded the brown no more changed its own colour. After this the mixture was placed in a warm temperature, where the white precipitate, which was owing to the nitrated mercury added in excess, again gradually disappeared. The brown precipitate, which fell to the bottom as a heavy powder, was the gold sought for. When collected and fused with nitrate of potash, it gave a bead of pure gold, weighing 41½ grains.

(*g.*) The liquor was now saturated with carbonate of soda, in a boiling heat. A copious bluish-gray precipitate ensued, which turned black-brown by ignition. Digested with muriatic acid, it dissolved again clearly, and gave out oxygenated muriatic acid gas. By combining this solution with liquid carbonate of ammonia to a considerable degree of supersaturation, a grayish-white precipitate was produced; which, collected, washed, and dried, weighed 92 grains, and proved to be a somewhat iron-shot carbonated oxide of manganese.

(*h.*) The ammoniacal lixivium (*g.*) appeared of a blue colour. After being supersaturated with sulphuric acid, by which it was again rendered colourless, a small plate of polished iron was introduced, and the vessel put in a warm place. The iron became gradually coated with copper, the weight of which after drying was six grains.

Therefore the 1000 grains were decomposed into		Exclusive of the matrix of quartz and manganesian ore.
Lead (*d*),	248·0	54·0
Tellurium (*c*),	148·0	32·2
Gold (*f*),	41·5	9·0
Silver (*c*),	2·5	0·5
Copper (*h*),	6·0	1·3
Sulphur (*b*),	14·0	3·0
Oxide of manganese (*g*),	92·0	——
Quartz (*c*),	437·0	100·0
	989·0	
Loss,	11·0	
	1000·0	

6. Iron Ores are usually analyzed by fusion. On this subject there is a valuable essay by Mr. Mushet, in the 4th volume of the Phil. Magazine. In the hematites iron ore, for 1 pound avoirdupois, he commonly added 6 ounces dried chalk, and ¾ of an ounce of charcoal; and for the splinty blue ore also a similar mixture. From both of these mixtures he obtained the richest sort of crude iron. The kidney ore will admit of a diminution of chalk, and a small addition of glass. One pound avoirdupois of this variety will be accurately assayed by the addition of 5 ounces chalk, 1 ounce glass, and ¾ of an ounce of charcoal. The same proportion of mixtures will also accurately reduce the small pieces of this ore, commonly of a soft greasy consistence, mixed with small fragments of the hematites and the kidney, and will give out the iron which they contain supercarburetted. A mixture of this soft ore, with kidney, is preferred to the richer variety at the iron manufactories. The Lancashire ore consists chiefly of this compound, and the poorer in iron has always a decided preference given it at the blast-furnace. The Elba ore may be reduced into smooth carburetted iron, by exposing to a melting heat 2 ounces of it mixed with 2 ounces of chalk, 1½ ounce bottle-glass, and ¼ ounce of charcoal. To the Islay iron ore, and the Norwegian, Danish, and Swedish, Mr. Mushet adds, for every pound, 7 ounces of dried chalk, 3 of bottle-glass, and 1 of charcoal. By carburetted iron is meant cast-iron.

I shall now give an outline of Mr. Hatchett's much admired analysis of the magnetical pyrites.

(*a.*) 100 grains reduced to a fine powder, were digested with two ounces of muriatic acid, in a glass matrass placed in a sand-bath. A strong effervescence ensued, occasioned by the production of sulphuretted hydrogen gas; and a pale yellowish-green solution was formed. The residuum was then again digested with two parts of muriatic acid, mixed with one of nitric acid; and a quantity of pure sulphur was obtained, which, being dried, weighed 14 grains.

(*b.*) The acid in which the residuum had been digested was added to the first muriatic solution; some nitric acid was also poured in to promote the oxidizement of the iron, and thereby to facilitate the precipitation of it by ammonia, which was added after the liquor had been boiled for a considerable time. The precipitate thus obtained was boiled with lixivium of potash; it was then edulcorated, dried, made red-hot with wax in a covered porcelain crucible, and completely taken up by a magnet, and being weighed, amounted to 80 grains.

(*c.*) The lixivium of potash was examined by muriate of ammonia, but no alumina was obtained.

(*d.*) To the filtered liquor, from which the iron had been precipitated by ammonia, muriate of barytes was added, until it ceased to produce any precipitate; this was then digested with some very dilute muriatic acid; was collected, washed, and after exposure to a low red heat for a few minutes in a crucible of platinum, weighed 155 grains. If therefore the quantity of sulphur converted into sulphuric acid by the preceding operations, and precipitated by barytes, be calculated according to the experiments of M. Chenevix, then 155 grains of sulphate of barytes will denote nearly 22·5 of sulphur (21. Dr. Wollaston's scale); so that with the addition of the 14 grains previously obtained in substance, the total quantity will amount to 36·5 (35).

(*e.*) Moreover, from what has been stated, it appears, that the iron which was obtained in the form of black oxide weighed 80 grains; and by adding these 80 grains to the 36·5 of sulphur, an increase of weight is found = 16.5. This was evidently owing to the oxidizement of the iron, which in the magnetical pyrites exists quite or very nearly in the metallic state; but by the operations of the analysis has received this addition. The real quantity of iron must on this account be estimated at 63·5.

100·0 97·22

This analysis was repeated in a similar manner, excepting that the whole was digested in nitric acid, until the sulphur was entirely converted into sulphuric acid. To the liquor which remained after the separation of the iron by ammonia, muriate of barytes was added, as before, and formed a precipitate which weighed 245 grains. Now these, by Dr. Wollaston's scale, are equivalent to nearly 33·5 of sulphur. Hence it would appear, that a little sulphur is dissipated in the form of sulphurous acid, by this mode of operation.

The theoretical equivalent proportions of magnetic pyrites are,

Sulphur,	36·363	2·00
Iron,	63·636	3·50

We thus see, that Mr. Hatchett's final statement is almost exact, in consequence of M. Chenevix's erroneous estimate of the composition of sulphuric acid and sulphate of barytes, making a compensation for the experimental deviation, or loss; amounting on the iron to 1·416, and on the sulphur to 1·363, in the 100 parts.

Analysis of arseniate of iron, by M. Chenevix:—

100 grains boiled with potash left 58·5. The liquor treated by nitrate of lead gave of arseniate of lead a quantity which he estimated as equivalent to 31 of arsenic acid. The 58·5 left 4, which muriatic acid could not dissolve, and which were silica. Ammonia dissolved 9, and there remained 45·5 of oxide of iron. This analysis presents the following results:—

Arsenic acid, -	31·00
Oxide of iron, -	45·50
Oxide of copper, -	9·00
Silica, - - - -	4.00
Water, by inference,	10·50
	100·00

7. **Lead Ore.** Analysis of yellow lead ore from Wanlockhead, by Klaproth:—

(*a.*) Upon 100 grains of this ore, finely levigated, dilute nitric acid was poured and heated. They dissolved, and only a few inconsiderable flocks escaped the action of the solvent. The filtered colourless solution, when treated with nitrate of silver, gave $10\frac{1}{2}$ muriate of silver, which indicates, says Klaproth, 1·62 grains dry muriatic acid.

(*b.*) Sulphuric acid was then presented to the solution. It precipitated the lead contained in that fluid in the state of sulphate; which having suffered a red heat, weighed $108\frac{1}{8}$ grains; for which 80 grains of oxide of lead must be allowed.

phosphate of lead thus obtained, he inferred 18 grains of phosphoric acid to have existed in the ore.

The residuary part of the fluid contained nothing more of the constituent parts of the mineral, excepting a slight trace of iron. Consequently 100 gr. were resolved into—

Oxide of lead,	80.
Phosphoric acid,	18·
Muriatic acid,	1·62
	99·62

8. Analysis of **Gray Silver Ore**, by Klaproth:—

(*a.*) 300 grains of the fragments selected from the pounded ore, though not perfectly separable from the quartzose gangue, with which they were firmly concreted, were levigated to a subtile powder, and digested with four times their weight of nitric acid. The digestion was renewed with the residuum in an equal quantity of the same acid; and the portion which still remained undissolved then assumed a grayish-yellow colour, and weighed 188 grains.

(*b.*) By the addition of muriate of soda to the bright green nitric solution, its silver was thrown down; and this precipitate, collected and reduced by means of soda, yielded $31\frac{1}{2}$ grains of metallic silver.

(*c.*) The silver being thus separated, he tried the solution for lead; but neither the neutral sulphates, nor free sulphuric acid, could discover the least sign of it.

(*d.*) After this he added caustic volatile alkali, so as to supersaturate the acid; upon which a reddish-brown precipitate, of a loose cohesion, appeared, that by ignition became of a black-brown, and weighed $9\frac{1}{4}$ grains. It dissolved in nitric acid, leaving behind it half a grain of siliceous earth. Prussiate of potash produced from the filtered solution a deep blue precipitate of iron; and after this was separated, $1\frac{1}{2}$ grains of alumina were obtained from it by means of soda. Therefore, subtracting the siliceous and argillaceous earths, the portion of iron attractible by the magnet amounted to $7\frac{1}{4}$ grains.

(*e.*) To the solution, which had been before supersaturated with pure ammonia, and exhibited a sapphire-blue colour, sulphuric acid was now added to excess. A polished piece of iron was then immersed into the fluid, from which it precipitated 69 grains of copper.

(*f.*) The above grayish-yellow residuum (*a.*) was now to be examined. It was digested with six times its quantity of muriatic acid, in a heat of ebullition. When filtered, the residue which was left on the paper, being by the last process, and was of a straw-yellow, the greater part of the fluid was drawn off by gentle distillation in a retort. The remaining concentrated solution then deposited some crystalline grains, which were carefully collected, and proved upon inquiry to be muriate of silver, weighing one-fourth of a grain. A large quantity of water being next poured into the solution, a copious precipitate subsided, weighing after desiccation 97¼ grains. It proved by every test to be oxide of antimony, for which, as was found by comparative experiments, 75 grains of reguline antimony must be allowed.

(*h.*) The residue obtained (*f.*), weighing 105½ grains, which comprised the sulphureous part of the ore, was exposed to a low heat, by which treatment the sulphur was consumed, and 80¼ grains of silica remained. Hence the quantity of the sulphur was equal to 25¼ grains.

(*i.*) The siliceous earth was next fused with four times its weight of black flux. The melted mass entirely dissolved in twice its weight of water into liquor of flints; some minute particles of silver, weighing three-fourths of a grain, excepted. According to this, the proportion of silica amounted to 79½ grains.

The whole constituents therefore are,—

				Ore, exclusive of silica, in 100
Silver,	(*b*)	31.5	32.50	14.77
	(*g*)	0.25		
	(*i*)	0.75		
Copper,	(*e*)		69.00	31.36
Antimony,	(*g*)		75.00	34.09
Iron,	(*d*)		7.25	3.30
Sulphur,	(*h*)		25.25	11.50
Alumina,	(*d*)		1.50	0.30
				95.52
Silica,	(*d*) and (*i*)		80.00	

9. Analysis of TIN ORES by Klaproth:—

1. Tinstone.

(*a.*) 100 grains of tinstone from Alternon, in Cornwall, previously ground to a subtile powder, were mixed in a silver vessel, with a lixivium containing 600 grains of caustic potash. This mixture was evaporated to dryness in a sand heat, and then moderately ignited for half an hour. When the gray-white mass thus obtained had been softened while yet warm with boiling water, it left on the filter 11 grains of an undissolved residue.

(*b.*) These 11 grains again ignited with 6 times their weight of caustic potash, and dissolved in boiling water, left now only 1¼ grains of a fine yellowish-gray powder behind.

(*c.*) The alkaline solution (*a* and *b*), which was in some degree colourless, was saturated with muriatic acid. A brilliant white tender of carbonate of soda. When lixiviated and dried in a gentle heat, it acquired the form of bright-yellowish transparent lumps, having in their fracture a vitreous lustre.

(*d.*) This precipitate being finely powdered, soon dissolved entirely in muriatic acid, assisted by a gentle heat. Into the colourless solution, previously diluted with from 2 to 3 parts of water, he put a stick of zinc; and the oxide of tin, thus reduced, gathered around it, in delicate dendritic laminæ, of a metallic lustre. These, when collected, washed, dried, and fused under a cover of tallow, in a capsule placed upon charcoal, yielded a button of pure metallic tin, weighing 77 grains.

(*e.*) The above mentioned residue of 1¼ grains, left by the treatment with caustic potash (*b.*), afforded with muriatic acid a yellowish solution; from which, by means of a little piece of zinc introduced into it, ½ grain of tin was still deposited. Ferroprussiate of potash added to the remainder of the solution produced a small portion of a light blue precipitate; of which, after deducting the oxide of tin, now combined with it, hardly ¼ of a grain remained to be put to the account of the iron contained in the tinstone here examined.

In these experiments, (excepting only a slight indication of silex, amounting to about ¾ of a grain), no trace appeared either of tungstic oxide, which some mineralogists have supposed to be one of the constituent parts of tinstone, nor of any other fixed substance. Therefore what is deficient in the sum, to make up the original weight of the mineral analyzed, must be ascribed to the loss of oxygen; and thus the constituent parts of pure tinstone from Alternon are to each other in the following proportion:

Tin,	77.50
Iron,	0.25
Silica	0.75
Oxygen,	21.50
	100.00

2. Tin pyrites, from Wheal-Rock, St. Agnes, in Cornwall.

(*a.*) 120 grains of finely triturated tin pyrites were treated with an aqua regia, composed of 1 ounce muriatic acid, and ½ ounce of nitric acid. Within 24 hours the greatest part of the metallic portion was dissolved in it, without application of heat; while the sulphur rose up and floated on the surface of the menstruum. After the mixture had been digested upon it for some time in a low sand heat, it was diluted with water, and thrown on a filter. It left 43 grains of sulphur on the paper, still, however, mixed with metallic particles. When the sulphur had been gently burnt off on a test, there still remained

13 grains; of which 8 were dissolved by nitro-muriatic acid. The remaining part was then ignited with a little wax; upon which the magnet attracted 1 grain of it. What remained was part of the siliceous matrix, and weighed 3 grains.

(*b.*) The solution of the metallic portion (*a.*) was combined with carbonate of potash; and the dirty-green precipitate thus obtained was redissolved in muriatic acid, diluted with 3 parts of water. Into this fluid a cylinder of pure metallic tin, weighing 217 grains, was immersed. The result was, that the portion of copper contained in the solution deposited itself on the cylinder of tin; at the same time that the fluid began to lose its green colour, from the bottom upwards, until, after the complete precipitation of the copper in the reguline state, it became quite colourless.

(*c.*) The copper thus obtained weighed 44 grains. By brisk digestion in nitric acid it dissolved, forming a blue tincture, and left 1 grain of tin behind, in the character of a white oxide. Thus the portion of pure copper consisted of 43 grains.

(*d.*) The cylinder of tin employed to precipitate the copper now weighed 128 grains; so that 89 grains of it had entered into the muriatic solution. From this, by means of a cylinder of zinc, he reproduced the whole of the dissolved tin, which was loosely deposited upon the zinc in a tender dendritical form. When the tin was all precipitated, he collected and lixiviated carefully, and suffered it to dry. It weighed 130 grains. By mixing it with tallow, he melted it into grains, under a cover of charcoal dust, in a small crucible; and separated the powder of the coal by elutriation. Among the washed grains of tin some black particles of iron were observed, which were attractible by the magnet, and weighed 1 grain. Deducting this, there remain 129 grains for the weight of the tin. By subtracting again from these last those 89 grains, which proceeded from the cylinder of tin employed for the precipitation of the copper (*b.*), there remained 40 grains, for the portion of tin contained in the tin pyrites examined. Hence, including the 1 grain of tin which had been separated from the solution of the copper (*c.*), the portion of pure tin contained in this ore amounted to 41 grains. The following is a view of the results:—

	In 120 gr.	In 100.
Sulphur,	30	25
Tin,	41	34
Copper,	43	36
Iron,	2	2
Gangue,	3	—
	—	97
	119	

The darker varieties are considerably poorer in tin. The reduction of the ores of tin is effected, by roasting the ore after it has been pulverized in stamping mills, and then exposing it to heat in a reverberatory or blast furnace, along with Welsh small coal or culm. If much copper be present, it is afterwards fused at a very gentle heat, and what flows off is pretty pure tin.

Zinc is reduced by distillation of its ore (previously roasted) in a retort, along with charcoal.

A sulphuret of zinc was lately met with in one of the Gwennap mines, incrusting a spongy pyrites intermixed with quartz, and so like wood-tin as to be supposed a variety of it by the miners. According to Dr. Kidd, it consists of 66 oxide of zinc, 33 sulphur, and a very minute portion of iron. The pyrites contains cobalt.

In the dry way, zinc is reduced by distilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a strong heat: but by this method scarce half the zinc it contains is obtained.

The first dressing of calamine for the large works of zinc consists in picking out all the pieces of lead ore, lime, and ironstone, cauk, and other heterogeneous substances, which are found mixed with it in the mine: it is then roasted in proper furnaces, where it loses about a third or fourth part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more discernible by the action of the fire; it is then ground to a fine powder, and washed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; so that, by these processes, a ton of the crude calamine of Derbyshire is reduced to 12 cwt. only.

Bergmann affirms, that a certain Englishman, whose name he does not mention, made, several years ago, a voyage to China, for the purpose of learning the art of smelting zinc, or tutenague; and that he became instructed in the secret, and returned safely home.

It is not improbable but that a fact of this kind may have served to establish the manufactory of zinc in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the first work of the kind near Bristol. It consists, as Watson relates, of a circular kind of oven, like a glass-house furnace, in which were placed six pots, of about four feet each in height, much resembling large oil jars in shape: into the bottom of each pot is inserted an iron tube, which passes through the floor of the furnace, into a vessel of water. A mixture of the prepared ore is made with charcoal, and the pots are filled with it to the mouth, which are then close stopped with strong covers and luted with clay. The fire being properly applied, the metallic vapour of the calamine issues downwards, or *per descensum*, through the iron tubes, there being no other place through which it can escape;

and the air being excluded, it does not take fire, but is condensed in the water into granulated particles; which, being remelted, are cast into ingots, and sent to Birmingham under the name of zinc, or spelter; although by this last name of spelter only a granulated kind of soft brass is understood among the braziers, and others who work in London, used to solder pieces of brass together.

ORICHALCUM. The brass of the ancients; their *æs* was a species of bronze.

ORPIMENT. Sulphuret of arsenic. See Ores of Arsenic.

ORTHITE. A mineral so named because it always occurs in straight layers, generally in felspar. It resembles gadolinite, and consists of, peroxide of cerium 19.5, protoxide of iron 12.44, protoxide of manganese 3.44, yttria 3.44, silica 32.0, alumina 14.8, lime 7.84, water 5.36.—*Berzelius.* It is found in the mine of Finbo, in the vicinity of Fahlun in Sweden. The mine is situated in a vein of granite which traverses gneiss.

OSMAZOME. If cold water which has been digested for a few hours on slices of raw muscular fibre, with occasional pressure, be evaporated, filtered, and then treated with pure alcohol, a peculiar animal principle will be dissolved, to the exclusion of the salts. By dissipating the alcohol with a gentle heat, the osmazome is obtained. It has a brownish-yellow colour, and the taste and smell of soup. Its aqueous solution affords precipitates, with infusion of nut-galls, nitrate of mercury, and nitrate and acetate of lead.

OSMIUM. A new metal lately discovered by Mr. Tennant among platina, and thus called by him from the pungent and peculiar smell of its oxide. For the mode in which he extracted it, see Iridium.

Its oxide may likewise be obtained in small quantity by distilling with nitre the black powder left after dissolving platina; when at a low red heat an apparently oily fluid sublimes into the neck of the retort, which on cooling concretes into a solid, colourless, semitransparent mass. This being dissolved in water, forms a concentrated solution of oxide of osmium. This solution gives a dark stain to the skin that cannot be effaced. Infusion of galls presently produces a purple colour in it, which soon after becomes of a deep vivid blue. This is the best test of the oxide. With pure ammonia it becomes yellow, and slightly so with carbonate of soda. With lime it forms a bright yellow solution; but it is not affected either by chalk, or by pure magnesia. The solution with lime gives a deep red precipitate with galls, which is turned blue by acids. It produces no effect on solution of gold or platina; but precipitates lead of a yellowish-brown, mercury of a white, and muriate of tin of a brown colour.

Oxide of osmium becomes of a dark colour with alcohol, and after some time separates in the form of black films, leaving the alcohol without colour. The same effect is produced by ether, and much more quickly.

It parts with its oxygen to all the metals except gold and platina. Silver kept in a solution of it some time acquires a black colour, but does not deprive it entirely of smell. Copper, tin, zinc, and phosphorus, quickly produce a black or gray powder, and deprive the solution of smell, and of the property of turning galls blue. This black powder, which consists of the metallic osmium, and the oxide of the metal employed to precipitate it, may be dissolved in nitromuriatic acid, and then becomes blue with infusion of galls.

If the pure oxide dissolved in water be shaken with mercury, it soon loses its smell, and the metal forms a perfect amalgam. By squeezing the superfluous mercury through leather, and distilling off the rest, a dark gray or blue powder is left, which is the osmium.

Exposed to a strong heat in a cavity in a piece of charcoal, it does not melt; nor is it volatile, if oxidation be carefully prevented. With copper and with gold it forms malleable alloys, which are easily dissolved in nitromuriatic acid, and afford by distillation the oxide of osmium. The pure metal, previously heated, did not appear to be acted upon by acids. Heated in a silver cup with caustic alkali, it combined with it, and gave a yellow solution, similar to that from which it was procured. From this solution acids separate the oxide of osmium.—*Phil. Trans.*

OSSIFICATIONS. The deposition of calcareous phosphate or carbonate on the soft solids of animal bodies; as in the pineal gland, lungs, liver, &c. See Pulm. Concretions.

OURETIC ACID. A supposed new acid of Proust and Bergmann, shown by Klaproth to be biphosphate of soda.

OXALATES. Compounds of the salifiable bases with oxalic acid. See Acid (Oxalic), and the bases.

OXALIC ACID. This acid is described under Acid (Oxalic). It is found in the state of oxalate of lime in the roots of the following plants:—Alkana, apium, bistorta, carlina acaulis, curcuma, dictamnus albus, fœniculum, gentiana rubra, vincetoxicum, lapathum, liquiritia, mandragora, ononis, iris florentina, iris nostras, rheum, saponaria, scilla, sigillum salomonis, tormentilla, valeriana, zedoaria, zingiber. And in the following barks:—berberis, cassia fistularis, canella alba, cinamomum, cascarilla, cassia caryophyllata, china, culilavan, frangula, fraxinus, quassia, quercus, simaruba, lignum sanctum, ulmus. In the state of binoxylate of potash it exists in the leaves of the oxalis acetosella, oxalis corniculata, different species of rumex, and geranium acidum.

The juice of the cicer parietinum is said to be pure oxalic acid.

OXIDATION. The process of converting metals or other substances into oxides, by combining with them a certain portion of oxygen. It differs from *acidification* in the addition of oxygen not being sufficient to form an acid with the substance oxidized.

OXIDES. Substances combined with oxygen, without being in the state of an acid.

OXYGEN GAS. This gas was obtained by Dr. Priestley in 1774 from red oxide of mercury exposed to a burning lens, who observed its distinguishing properties of rendering combustion more vivid and eminently supporting life. Scheele obtained it in different modes in 1775; and in the same year Lavoisier, who had begun, as he says, to suspect the absorption of atmospheric air, or of a portion of it, in the calcination of metals, expelled it from the red oxide of mercury heated in a retort.

Oxygen gas forms about a fifth of our atmosphere, and its base is very abundant in nature. Water contains 88·88 per cent. of it; and it exists in most vegetable and animal products, acids, salts, and oxides.

This gas may be obtained from nitrate of potash, exposed to a red heat in a coated glass or earthen retort, or in a gun-barrel; from a pound of which about 1200 cubic inches may be obtained; but this is liable, particularly toward the end of the process, to a mixture of nitrogen. It may be expelled, as already observed, from the red oxide of mercury, or that of lead; and still better from the black oxide of manganese, heated red-hot in a gun-barrel, or exposed to a gentle heat in a retort with half its weight, or somewhat more, of strong sulphuric acid. To obtain it of the greatest purity, however, the chlorate of potash is preferable to any other substance, rejecting the portions that first come over as being debased with the atmospheric air in the retort. Growing vegetables, exposed to the solar light, give out oxygen gas; so do leaves laid on water in similar situations, the green matter that forms in water, and some other substances.

Oxygen gas has neither smell nor taste. Its sp. gr. is 1·1111; 100 cubic inches weigh 33·88 gr. It is a little heavier than atmospheric air. Under great pressure water may be made to take up about half its bulk. It is essential to the support of life: an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the whole is consumed, and it dies, though a fresh animal of the same kind can still sustain life for a certain time in the residuary air.

Combustion is powerfully supported by oxygen gas. Any inflammable substance, previously kindled, and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxygen gas, with a bit of lighted touchwood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that these sparks may not crack it. If the wire coiled up in a spiral like a corkscrew, as it usually is in this experiment, be moved with a jerk the instant a melted globule is about to fall, so as to throw it against the side of the glass, it will melt its way through in an instant, or, if the jerk be less violent, lodge itself in the substance of the glass. If it be performed in a bell glass, set in a plate filled with water, the globules will frequently fuse the vitreous glazing of the plate, and unite with it so as not to be separable without detaching the glaze, though it has passed through perhaps two inches of water.

OXYGENATION. This word is often used instead of oxidation, and frequently confounded with it; but it differs in being of more general import, as every union with oxygen, whatever the product may be, is an oxygenation; but oxidation takes place only when an oxide is formed.

OXYMEL. A compound of honey and vinegar.

OXYMURIATIC ACID. CHLORINE.

OXYPRUSSIC ACID. See ACID (CHLOROPRUSSIC).

P

PAINTS. In the Philosophical Transactions for 1815, Sir H. Davy has communicated the results of some interesting researches, which he had made at Rome, on the colours used by the ancient artists.

He found the reds to be minium, ochre, and cinnabar.

The yellows were ochre, orpiment, and massicot.

The blues were formed from carbonate of copper, or cobalt, vitrified with glass.

The purples were made of shell-fish, and probably also from madder and cochineal lakes.

The blacks and browns were lamp-black, ivory-black, and ores of iron and manganese.

The whites were chalk, white clay, and ceruse.

The Egyptian azure, the excellence of which is proved by its duration for seventeen hundred years, may be easily and cheaply made. Sir H. Davy found, that 15 parts by weight of carbonate of soda, 20 of powdered opaque flints, and 3 of copper filings, strongly heated together for two hours, gave a substance of exactly the same tint, and of nearly the same degree of fusibility, and which when powdered produced a fine deep sky-blue.

He conceives that, next to coloured frits, the most permanent pigments are those furnished by the peroxides, or persalts, such as ochres, carbonates of copper, patent yellow (submuriate of lead), chromate of lead, arsenite of copper, insoluble chloride of copper, and sulphate of barytes.

M. Merimé has inserted a note very interesting to painters in the *Annales de Chimie et de Phys.* for June 1820. When carbonate of lead is exposed for some time to vapours of sulphuretted hydrogen, it becomes black, being converted into a sulphuret. This white pigment, employed with oil, and covered with a varnish, which screens it from the air, may be preserved for many hundred years, as the paintings of the 15th century prove. But when the varnish is abraded or decays, the whites of ceruse are apt to contract black specks and spots, which ruin fine paintings. Miniatures in water colours are frequently injured in this way. M. Thenard was requested to occupy himself with the means of removing these stains, without injuring the rest of the picture. After some trials, which proved that the reagents which would operate on sulphuret of lead, would equally attack the texture of the paper, as well as other colours, he recollected, that among the numerous phenomena which his discovery of oxygenated water had presented to him, he observed the property it possessed of converting instantly the black sulphuret of lead into the white sulphate of the same metal. He gave a portion of water, containing about five or six times its volume of oxygen, to an artist who had a fine picture of Raphael spotted black. On applying a few touches of his pencil, he perceived the stains vanish as if by enchantment, without affecting the other colours in the slightest degree.

PAKFONG. The white copper of the Chinese, said to be an alloy of copper, nickel, and zinc; in 16 parts of which there are 7 of zinc, $2\frac{1}{2}$ of copper, and $6\frac{1}{2}$ of nickel. The combination of zinc and nickel simply does not succeed.

PALLADIUM. This is a new metal, first found by Dr. Wollaston associated with platina, among the grains of which he supposes its ore to exist, or an alloy of it with iridium and osmium, scarcely distinguishable from the crude platina, though it is harder and heavier.

If crude platina be dissolved in nitro-muriatic acid, and precipitated with a solution of muriate of ammonia in hot water; the precipitate washed, and the water added to the remaining solution, and a piece of clean zinc be immersed in this liquid, till no farther action on it takes place; the precipitate now thrown down will be a black powder, commonly consisting of platina, palladium, iridium, rhodium, copper, and lead. The lead and copper may be separated by dilute nitric acid. The remainder being then digested in nitro-muriatic acid, and common salt about half the weight of the precipitate added on the solution, on evaporating this to dryness by a gentle heat, the result will be, triple salts of muriate of soda, with platina, palladium, and rhodium. Alcohol will dissolve the first and second of these, and the small portion of platina may be precipitated by sal ammoniac. The solution being diluted, and prussiate of potash added, a precipitate will be thrown down, at first of a deep orange, and afterward changing green. This being dried, and heated with a little sulphur before the blowpipe, fuses into a globule, from which the sulphur may be expelled by exposing it to the extremity of the flame, and the palladium will remain spongy and malleable.

It may likewise be obtained by dissolving an ounce of nitrate of potash in five of muriatic acid, and in this mixture digesting the compound precipitate mentioned above. Or more simply by adding to a solution of crude platina, a solution of prussiate of mercury, on which a flocculent precipitate will gradually be formed, of a yellowish-white colour. This is prussiate of palladium, from which the acid may be expelled by heat.

Palladium is of a grayish-white colour, scarcely distinguishable from platina, and takes a good polish. It is ductile and very malleable; and being reduced into thin slips is flexible, but not very elastic. Its fracture is fibrous, and in diverging striæ, showing a kind of crystalline arrangement. In hardness it is superior to wrought iron. Its sp. gr. is from 10.9 to 11.8. It is a less perfect conductor of caloric than most metals, and less expansible, though in this it exceeds platina. On exposure to a strong heat its surface tarnishes a little, and becomes blue; but an increased heat brightens it again. It is reducible *per se*. Its fusion requires a much higher heat than that of gold; but if touched while hot with a small bit of sulphur, it runs like zinc. The sulphuret is whiter than the metal itself, and extremely brittle.

Nitric acid soon requires a fine red colour from palladium, but the quantity it dissolves is small. Nitrous acid acts on it more quickly and powerfully. Sulphuric acid, by boiling, acquires a similar colour, dissolvinga small portion. Muriatic acid acts much in the same manner. Nitro-muriatic acid dissolves it rapidly, and assumes a deep red.

Alkalis and earths throw down a precipitate from its solutions, generally of a fine orange colour; but it is partly redissolved in an excess of alkali. Some of the neutral salts, particularly those of potash, form with it triple compounds, much more soluble in water than those of platina, but insoluble in alcohol.

Alkalis act on palladium even in the metallic state; the contact of air, however, promotes their action.

A neutralized solution of palladium is precipitated of a dark orange or brown by recent muriate of tin: but if it be in such proportions as to remain transparent, it is changed to a beautiful emerald-green. Green sulphate of iron precipitates the palladium in a metallic state. Sulphuretted hydrogen produces a dark brown precipitate; prussiate of potash an olive coloured; and prussiate of mercury a yellowish-white. As the last does not precipitate platina, it is an excellent test of palladium. This precipitate is from a neutral solution in nitric acid, and detonates at about 500° of Fahr. in a manner similar to gunpowder. Fluoric, arsenic, phosphoric, oxalic, tartaric, citric, and some other acids, with their salts, precipitate some of the solutions of palladium.

All the metals, except gold, silver, and platina, precipitate it in the metallic state.

PANACEUM DUPLICATUM, OR HOLSATICUM. Bisulphate of potash.

PANIFICATION. Process of bread-making. See BREAD.

PAPAW TREE. The juice of this tree is remarkable for containing fibrine.

PARANTHINE. Haüy's name for *Scapolite*.

PARENCHYMA. The green juicy layer of barks, which lies immediately under the epidermis of trees.

PARGASITE. COMMON ACTYNOLITE.

PARILLINE. The salifiable base of sarsaparilla, a new vegeto-alkali, said to have been discovered by M. Galileo Palotta. See *Journ. de Pharm.*, 1824, *p.* 543.

PAULITE. HYPERSTHENE.

PASTE. A glass made in imitation of the gems. M. Douault-Wieland has lately given the following directions for making them.

The base of all artificial stones is a compound of silex, potash, borax, red oxide of lead, and sometimes arsenic. Pure boracic acid, and colourless quartz, should be used. Hessian crucibles are better than those of porcelain. The fusion should be continued in a potter's furnace for 24 hours; the more tranquil and continued it is, the denser the paste and the greater its beauty.

Pastes.	1.	2.	3.	4.
Rock crystal,	4056 gr.	—	3456	3600
Minium,	6300	—	5328	—
Potash,	2154	1260	1944	1260
Borax,	276	360	216	360
Arsenic,	12	12	6	—
Ceruse of Clichy,	—	8508	—	8508
Sand,	—	3600	—	—

Topaz.	No. 1.	No. 2.
Very white paste,	1008	3456
Glass of antimony,	43	—
Cassius purple,	1	—
Peroxide of iron (saffron of Mars),	—	36

Ruby.—Paste 2880, oxide of manganese 72. *Emerald.*—Paste 4608, green oxide of copper 42, oxide of chrome 2. *Sapphire.*—Paste 4608, oxide of cobalt 68, fused for 30 hours. *Amethyst.*—Paste 4608, oxide of manganese 36, oxide of cobalt 24, purple of Cassius 1. *Beryl.*—Paste 3456, glass of antimony 24, oxide of cobalt 1½. *Styrian Garnet*, or ancient carbuncle.—Paste 512, glass of antimony 256, Cassius purple 2, oxide of manganese 2.

In all these mixtures, the substances should be blended by sifting, fused very carefully, and cooled very slowly, being left on the fire from 24 to 30 hours.

M. Lançon gives the following recipes:

Paste.—Litharge 100, white sand 75, potash 10. *Emerald.*—Paste 9216, acetate of copper 72, peroxide of iron 1·5. *Amethyst.*—Paste 9216, oxide of manganese from 15 to 24, oxide of cobalt 1.

PEARL. A highly prized spherical concretion, which is formed within certain shell-fish. It has a bluish-white colour, with considerable lustre and iridescence. It consists of alternating concentric layers of membrane and carbonate of lime. To this lamellar structure the iridescence is to be ascribed. Pearls are of course very soluble in acids.

PEARL ASH. An impure potash, obtained by lixiviation from the ashes of plants.

PEARL SPAR. See BROWN SPAR.

PEARLSTONE. A sub-species of indivisible quartz of Jameson and Mohs.

Colour generally gray. Massive, vesicular, and in coarse concretions, whose surface is shining and very like pearl. In the centre of these concretions, spheres of obsidian are frequently met with. Lustre shining. Translucent on the edges. Most easily frangible. Soft. Sp. gr. 2·24 to 2·34. Before the blowpipe it swells, and passes into a frothy glass. Its constituents are, silica 75·25, alumina 12, oxide of iron 1·6, potash 4·5, lime 0·5, water 4·5.—*Klaproth.* It occurs in great beds in clay-porphyry near Tokay in Hungary, and near Sandy Brae in Ireland.

PEARL SINTER, OR FIORITE. A variety of siliceous sinter. Colours white and gray. In imitative shapes. Glistening; between resinous and pearly. In thin concentric concretions. Translucent. Scratches glass, but less hard than quartz. Brittle. Sp. gr. 1.917. It is infusible before the blowpipe. Its constituents are, silica 94, alumina 2, lime 4.—*Santi.* It has been found on volcanic tuff on the Vicentine.

PEASTONE. A variety of Limestone, which see.

PECHBLENDE. An ore of uranium.

PELIOM. A blue coloured mineral, massive or crystallized, in six-sided prisms. Fracture imperfect conchoidal. Cleavage fourfold. Lustre vitreous; translucent; hard as quartz, but brittle. Sp. gr. 2·54 to 2·6. Becomes electric by heating. Fuses with intumescence before the blowpipe into a transparent bead. Its constituents are, silica 49, alumina 33, magnesia 11·5, oxide of iron 4·33, manganese a trace, water 1·2.—*Stromeyer.* It occurs at Bodenmais in Bavaria. Iolite seems to be the same mineral, or a variety of it.

PEPPER. According to M. Pelletier, this substance consists of, 1. piperine; 2. a very acrid concrete oil; 3. a volatile balsamic oil; 4. a gummy coloured matter; 5. an extractive principle; 6. malic and tartaric acids; 7. starch; 8. bassorine; 9. lignine; 10. earthy and alkaline salts. He affirms that there is no vegeto-alkaline pepper. See Piperine.

PERCHLORIC ACID. See Acid (Muriatic).

PERICARDIUM (Liquor of the). The constituents of the liquor pericardii appear to be

Water, -	92·0	
Albumen, -	5·5	
Mucus, -	2·0	The proportion of these substances is somewhat conjectural.
Muriate of soda,	0·5	
	100·0	

PERIDOT. Chrysolite.

PERLATE SALT AND ACID. See Acid (Phosphoric).

PERLATED ACID, OR OURETIC. Biphosphate of soda.

PERU (Balsam of). This substance is obtained from the myroxylon peruiferum, which grows in the warm parts of South America. The tree is full of resin, and the balsam is obtained by boiling the twigs in water. It has the consistency of honey, a brown colour, an agreeable smell, and a hot acrid taste.

PERUVIAN BARK. See Cinchona.

PETALITE. A mineral discovered in the mine of Uto in Sweden by M. D'Andrada, interesting, from its analysis by M. Arfredson having led to the knowledge of a new alkali. Externally it resembles white quartz, but it has a twofold cleavage, parallel to the sides of a rhomboidal prism; two of which parallel to each other are splendent, and the other two are dull. Sp. gr. 2·45. On minute inspection, a pinkish hue may be discerned in the white colour. It scratches glass, but may be rased by a knife. It is scarcely fusible by the blowpipe, acquiring merely a glazed surface, full of minute bubbles. When reduced to a fine powder, it appears as white as snow. Placed in nitric acid, sp. gr. 1·45, it loses its white colour, and changes to a dingy hue; the acid at the same time becomes clouded. The same acid, somewhat dilute, dissolves it without effervescence at a boiling heat. Its constituents, by M. Arfredson, are, silex 79·212, alumina 17·225, lithia 5·761. There is here an excess of 2·198 above the hundred parts, which M. Arfredson says he does not know how to account for. M. Vauquelin found 7 *per cent.* of lithia in some pure specimens of petalite which M. Berzelius sent him. Dr. Gmelin, as well as M. Arfredson, state the sp. gr. at 2·42. Borax dissolves it with facility. The bead is transparent and colourless. Nitre, fused with pure petalite, does not betray the presence of any manganese; whence we may infer that it contains none of this metal. By Dr. Gmelin's analysis, petalite is composed of, silica 74·17, alumina 17·41, lithia 5·16, lime 0·32, moisture 2·17, and loss 0·77. He could detect no manganese in pure specimens. Those, however, of a pale rose-red colour contain it.

PETRIFACTIONS. Stony matters deposited either in the way of incrustation, or within the cavities of organized substances, are called petrifactions. Calcareous earth being universally diffused and capable of solution in water, either alone, or by the medium of carbonic acid or sulphuric acid, which are likewise very abundant, is deposited whenever the water or the acid becomes dissipated. In this way we have incrustations of limestone or of selenite in the form of stalactites or dropstones from the roofs of caverns, and in various other situations.

The most remarkable observations relative to petrifactions are thus given by Kirwan:—

1. That those of shells are found on, or near, the surface of the earth; those of fish deeper; and those of wood deepest. Shells in specie are found in immense quantities at considerable depths.

2. That those organic substances that resist putrefaction most are frequently found petrified; such as shells and the harder species of woods: on the contrary, those that are aptest to putrefy are rarely found petrified; as fish, and the softer parts of animals, &c.

3. That they are most commonly found in strata of marle, chalk, limestone, or clay, seldom in sandstone, still more rarely in gypsum; but never in gneiss, granite, basaltes, or shorle; but they sometimes occur among pyrites, and ores of iron, copper, and silver, and almost always consist of that

species of earth, stone, or other mineral that surrounds them, sometimes of silex, agate, or carnelian.

4. That they are found in climates where their originals could not have existed.

5. That those found in slate or clay are compressed and flattened.

PETROLEUM. See NAPHTHA.

PETROSILEX. Compact felspar.

PETUNTSE. Porcelain clay.

PEWTER, which is commonly called *étain* in France, and generally confounded there with true tin, is a compound metal, the basis of which is tin. The best sort consists of tin alloyed with about a twentieth or less of copper or other metallic bodies, as the experience of the workmen has shown to be the most conducive to the improvement of its hardness and colour, such as lead, zinc, bismuth, and antimony. There are three sorts of pewter, distinguished by the names of plate, trifle, and ley-pewter. The first was formerly much used for plates and dishes; of the second are made the pints, quarts, and other measures of beer; and of the ley-pewter, wine measures and large vessels.

The best sort of pewter consists of 17 parts of antimony to 100 parts of tin; but the French add a little copper to this kind of pewter. A very fine silver-looking metal is composed of 100 pounds of tin, eight of antimony, one of bismuth, and four of copper. On the contrary, the ley-pewter, by comparing its specific gravity with those of the mixtures of tin and lead, must contain more than a fifth part of its weight of lead.

PHARMACOLITE. Arsenic bloom. Native arseniate of lime. See ORES.

PHILLIPSITE. A new mineral accompanying Herschelite. Form of the crystals the same as *Harmotome;* but Phillipsite contains silica, alumina, potash, and lime, without any trace of barytes, as is manifest by putting a drop of sulphuric acid into their solutions in the nitric or muriatic.—*Annals of Phil.* x. 362.

PHLOGISTON. The supposed general inflammable principle of Stahl. See COMBUSTION.

PHLOGISTICATED GAS. Nitrogen, or azote.

PHLOGISTICATED ALKALI. Prussiate of potash.

PHOSGENE GAS. CHLOROCARBONOUS ACID.

PHOSPHATE OF YTTRIA. A mineral found by M. Tank in the neighbourhood of Lindenas in Norway. Its colour is yellowish-brown. Sp. gr. 4·5577. It is scratched by steel. Fracture foliated in several directions. Externally dull; foliated fracture resinous lustre; transverse, greasy. In minute fragments, semi-transparent and yellowish. At the blowpipe, it resembles phosphate of lime. With borax, it affords a colourless bead, which becomes milky by cooling. The acids, even when concentrated, do not dissolve it. Its constituents are, by the analysis of Berzelius,

Yttria, - - -	62·58
Phosphoric acid with a little fluoric,	33·49
Subphosphate of iron, -	3·93
	100·00

PHOSPHORESCENCE. See LIGHT.

PHOSPHORITE. A sub-species of apatite.

1. *Common phosphorite.* Colour yellowish-white. Massive and in curved lamellar concretions. Surface drusy. Dull. Fracture uneven. Opaque. Soft and rather brittle. It melts with difficulty into a white-coloured glass. When rubbed in an iron mortar, or thrown on red-hot coals, it emits a green-coloured phosphoric light. Its constituents are, lime 59, phosphoric acid 34, silica 2, fluoric acid 1, oxide of iron 1.—*Pelletier.* It occurs in crusts in Estremadura in Spain.

2. *Earthy phosphorite.* Colour grayish-white. It consists of dull dusty particles. It phosphoresces on glowing coals. Its constituents are, lime 47, phosphoric acid 32·25, fluoric acid 2·25, silica 0·5, oxide of iron 0·75, water 1, mixture of quartz and loam 11·5.—*Klaproth.* It occurs in a vein at Marmarosch in Hungary. See APATITE.

PHOSPHORUS. If phosphoric acid be mixed with 1-5th of its weight of powdered charcoal, and the mixture distilled at a moderate red heat, in a coated earthen retort, whose beak is partially immersed in a basin of water, drops of a waxy-looking substance will pass over, and, falling into the water, will concrete into the solid called phosphorus [*]. It must be purified, by straining it through a piece of chamois leather, under warm water. It is yellow and semi-transparent. It is as soft as wax, but fully more cohesive and ductile. Its sp. gr. is 1·77. It melts at 90° F. and boils at 550°.

In the atmosphere, at common temperatures, it emits a white smoke, which, in the dark, appears luminous. This smoke is acidulous, and results from the slow oxygenation of the phosphorus. In air perfectly dry, however, phosphorus does not smoke, because the acid which is formed is solid, and closely incasing the combustible, screens it from the atmospherical oxygen.

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[*] M. Javal finds, that the superphosphate of lime, obtained by digesting 5 parts of calcined bone powder with two parts of sulphuric acid, is better adapted to yield phosphorus by ignition with charcoal in a retort than pure phosphoric acid. The latter sublimes in a great measure undecomposed. *Ann. de Chim. et de Physique, June,* 1820.

When phosphorus is heated in the air to about 148°, it takes fire, and burns with a splendid white light, and a copious dense smoke. If the combustion take place within a large glass receiver, the smoke becomes condensed into snowy looking particles, which fall in a successive shower, coating the bottom plate with a spongy white efflorescence of phosphoric acid. This acid snow soon liquefies by the absorption of aqueous vapour from the air.

When phosphorus is inflamed in oxygen, the light and heat are incomparably more intense; the former dazzling the eye, and the latter cracking the glass vessel. Solid phosphoric acid results; consisting of 4 phosphorus $+$ 5·0 oxygen, or 1 atom of phosphorus $+$ 5 of oxygen.

When phosphorus is heated in highly rarefied air, three products are formed from it: one is phosphoric acid; one is a volatile white powder; and the third is a red solid of comparative fixity, requiring a heat above that of boiling water for its fusion. The volatile substance is soluble in water, imparting acid properties to it. It seems to be phosphorous acid. The red substance is probably an oxide of phosphorus, since for its conversion into phosphoric acid it requires less oxygen than phosphorus does. See ACIDS (PHOSPHORIC, PHOSPHOROUS, and HYPOPHOSPHOROUS).

Phosphorous acid is composed of 1 atom phosphorus $+ 3$ oxygen $= 4 + 3 = 7$.

Phosphorus and chlorine combine with great facility, when brought in contact with each other at common temperatures. When chlorine is introduced into a retort exhausted of air, and containing phosphorus, the phosphorus takes fire, and burns with a pale flame, throwing off sparks; while a white substance rises and condenses on the sides of the vessel.

If the chlorine be in considerable quantity, as much as 12 cubic inches to a grain of phosphorus, the latter will entirely disappear, and nothing but the white powder will be formed, into which about 9 cubic inches of the chlorine will be condensed. No new gaseous matter is produced.

The powder is a compound of phosphorus and chlorine, first described as a peculiar body by Sir H. Davy in 1810; and various analytical and synthetical experiments which he made with it, prove that it consists of about 1 phosphorus, and 6.8 chlorine in weight. The equivalent ratio of 1 prime of the first $+$ 6 of the second constituent, gives 4 to 27, or 1 to 6·75. It is the bichloride of phosphorus.

This case shows the necessity in chemistry of abiding by experiment; for Sir H. Davy's untrimmed result, which had been called in question or lightly esteemed by the ultra-atomists, who pitched on 1.5 for the prime equivalent of phosphorus, is now seen to accord perfectly with the corrected prime equivalent of Dumas.

Its properties are very peculiar. It is snow-white, extremely volatile, rising in a gaseous form at a temperature much below that of boiling water. Under pneumatic pressure it may be fused, and then it crystallizes in transparent prisms.

It acts violently on water, decomposing it, whence result phosphoric and muriatic acids; the former from the combination of the phosphorus with the oxygen, and the latter from that of the chlorine with the hydrogen of the water. It produces flame when exposed to a lighted taper. If it be transmitted through an ignited glass tube, along with oxygen, it is decomposed, and phosphoric acid and chlorine are obtained. The superior fixity of the acid above the chloride seems to give that ascendancy of attraction to the oxygen here, which the chlorine possesses in most other cases. Dry litmus paper exposed to its vapour in a vessel exhausted of air is reddened. When introduced into a vessel containing ammonia, a combination takes place, accompanied with much heat, and there results a compound, insoluble in water, undecomposable by acid or alkaline solutions, and possessing characters analogous to earths.

The protochloride of phosphorus was first obtained in a pure state, by Sir H. Davy, in the year 1809. If phosphorus be sublimed through corrosive sublimate, in powder in a glass tube, a limpid fluid comes over as clear as water, and having a specific gravity of 1.45. It emits acid fumes when exposed to the air, by decomposing the aqueous vapour. If paper imbued with it be exposed to the air, it becomes acid without inflammation. It does not redden dry litmus paper plunged into it. Its vapour burns in the flame of a candle. When mixed with water, and heated, muriatic acid flies off, and phosphorous acid remains. See ACID (PHOSPHOROUS). If it be introduced into a vessel containing chlorine, it is converted into the bichloride; and if made to act upon ammonia, phosphorus is produced, and the same earthy-like compound results as that formed by the bichloride and ammonia.

When phosphorus is gently heated in the protochloride, a part of it dissolves, and the fluid, on exposure to air, gives off acid fumes, from its action on atmospheric moisture, while a thin film of phosphorus is left behind, which usually inflames by the heat generated from the decomposition of the vapour. The first compound of this kind was obtained by MM. Gay Lussac and Thenard, by distilling phosphorus and calomel together, in 1808; and they imagined it to be a peculiar combination of phosphorus, oxygen, and muriatic acid. No experiments have yet ascertained the quantity of phosphorus which the protochloride will dissolve. Probably, says Sir H. Davy, a definite combination may be obtained, in which the proportion of chlorine will correspond to the proportion of oxygen in the oxide of phosphorus.

The compounds of iodine and phosphorus have been examined by Sir H. Davy and M. Gay Lussac.

Phosphorus unites to iodine with the disengagement of heat, but no light. One part of phosphorus and eight of iodine form a compound of a red orange-brown colour, fusible at about 212°, and volatile at a higher temperature. When brought in contact with water, phosphuretted hydrogen gas is disengaged, flocks of phosphorus are precipitated, and the water, which is colourless, contains, in solution, phosphorus and hydriodic acids.

One part of phosphorus and 16 of iodine produce a crystalline matter of a grayish-black colour, fusible at 84°. The hydriodic acid produced by bringing it in contact with water, is colourless, and no phosphuretted hydrogen gas is disengaged.

One part of phosphorus and 24 of iodine produce a black substance partially fusible at 115°. Water dissolves it, producing a strong heat, and the solution has a very deep brown colour, which is not removed by keeping it for some time in a gentle heat. With 1 phosphorus and 4 iodine, two compounds, very different from each other, are obtained. One of them has the same colour as that formed of 1 phosphorus + 8 iodine, and seems to be the same with it. It melts at 217.5°, and, when dissolved in water, yields colourless hydriodic acid, phosphuretted hydrogen, and phosphorus; which last precipitates in orange-yellow flocks. The other compound is a reddish-brown, does not melt at 212°, nor at a considerably higher temperature. Water has no sensible action on it. Potash dissolves it with the disengagement of phosphuretted hydrogen gas; and when aqueous chlorine is poured into the solution, it shows only traces of iodine. When heated in the open air, it takes fire and burns like phosphorus, emitting white vapours, without any iodine. When these vapours were condensed in a glass jar by M. Gay Lussac, he could perceive no iodine among them. This red substance is always obtained, when the phosphorus is in the proportion of 1 to 4 of iodine. M. Gay Lussac is inclined to consider it as identical with the red matter which phosphorus so often furnishes, and which is at present considered as an oxide. In whatever proportions the iodide of phosphorus has been made, it exhales, as soon as it is moistened, acid vapours, owing to the hydriodic acid formed by the decomposition of the water.

Such is the account of the iodides of phosphorus given by M. Gay Lussac. The combining ratios are somewhat uncertain.

Phosphuretted hydrogen. Of this compound there are two varieties: one, which may be called perphosphuretted hydrogen; another, protophosphuretted hydrogen.

1. *Perphosphuretted hydrogen.* Into a small retort filled with milk of lime, or potash water, let some fragments of phosphorus be introduced, and let the heat of an Argand flame be applied to the bottom of the retort, while its beak is immersed in the water of a pneumatic trough. Bubbles of gas will come over, which explode spontaneously with contact of air. It may also be procured by the action of dilute muriatic acid on phosphuret of lime. In order to obtain the gas pure, however, we must receive it over mercury. Its smell is very disagreeable. Its sp. grav. is 0.9022. 100 cubic inches weigh 27.5 gr. In oxygen, it inflames with a brilliant white light. In common air, when the gaseous bubble bursts the film of water, and explodes, there rises up a ring of white smoke, luminous in the dark. Water absorbs about 1-40th of its bulk of this gas, and acquires a yellow colour, a bitter taste, and the characteristic smell of the gas. When brought in contact with chlorine it detonates with a brilliant green light; but the products have never been particularly examined.

By transmitting a series of electric explosions through phosphuretted hydrogen, the phosphorus is precipitated, and hydrogen of the original gaseous volume remains. Hence the composition of the gas may be deduced, from a comparison of its specific gravity with that of hydrogen.

Phosphuretted hydrogen,	0.9022
Hydrogen,	0.0694
Phos. = difference of weight,	0.8328

Thus we perceive, that this compound consists of 0·8328 phosphorus + 0.0694 hydrogen; or 12 + 1; or 1.5 + 0.125 = 1.625, which is the weight of the sum of the primes, commonly called the weight of its atom. The gas may be likewise conveniently analyzed by nitrous gas, nitrous oxide, or oxygen. The preceding densities and proportions are those currently given by British writers, and are probably incorrect. See these numbers corrected by M. Dumas further on, and also in the general table of GASES.

2. *Protophosphuretted hydrogen.* It was discovered by Sir H. Davy in 1812. When the crystalline hydrate of phosphorous acid is heated in a retort out of the contact of air, solid phosphoric acid is formed, and a large quantity of subphosphuretted hydrogen is evolved. Its smell is fetid, but not so disagreeably so as that of the preceding gas. It does not spontaneously explode like it with oxygen; but at a temperature of 300° a violent detonation takes place. In chlorine it explodes with a white flame. Water absorbs

one-eighth of its volume of this gas. When potassium is heated in it, its volume is doubled, and the resulting gas is pure hydrogen. When sulphur is sublimed in 1 volume of it, a sulphuret of phosphorus is formed, and nearly 2 volumes of sulphuretted hydrogen are produced.

Such is the constitution of these two compounds of phosphorus and hydrogen as taught by our systematists, and confirmed to apparent demonstration by Dr. Thomson in his late work on the First Principles of Chemistry, I. 203. But it is to be feared that the *atomic* theory, misapplied, has here acted as a false light merely to mislead from the straight path of experiment. Accordingly, M. Dumas in an able memoir has adduced very decisive evidence of the inaccuracy of the above views, and has been led to conclude that protophosphuretted and perphosphuretted hydrogen contain each the same bulk of hydrogen, that is, $1\frac{1}{2}$ times their own volume; that the quantities of phosphorus with which that hydrogen is combined in the two gases are not in the ratio of 1 to 2, but of 2 to 3; that the ratio of 3 to 5, instead of 1 to 2, holds with regard to the oxygen in phosphorous and phosphoric acids, agreeably to the well-known determination of Berzelius; and, finally, that the gases obtained by heating phosphorous acid, or by leaving perphosphuretted hydrogen over water or mercury for a few days, are not different in their nature, but truly identical. I have thought it more instructive to present the results of M. Dumas in a supplementary form, whence they may be compared with those latterly adopted in this country.

1. *Protophosphuretted hydrogen.* This gas may be obtained perfectly pure by heating the phosphatic, phosphorous, or hypophosphorous acids, or by admitting fragments of phosphuret of lime or barytes to concentrated muriatic acid. But the gas disengaged from phosphuret of lime, by water alone, or by muriatic acid diluted with 10 times its weight of water, consists in the former case of perphosphuretted hydrogen 87 + hydrogen 13; and in the latter of perphosphuretted hydrogen 97 + water 7. Protophosphuretted hydrogen is not spontaneously combustible in air, as the other gas is.

100 measures of protophosphuretted hydrogen, heated with bichloride of mercury, afford 300 measures of muriatic acid gas, which contain 150 of hydrogen. But when 100 measures of that phosphuretted gas are heated in contact with sulphur, only 135 measures of sulphuretted hydrogen are obtained instead of 150; because 100 of sulphuretted hydrogen become 90 by being heated with sulphur; and 90 : 100 : : 135 : 150. From inattention to this important fact, several analytical errors have arisen. The detonation of protophosphuretted hydrogen mixed with oxygen is elegantly effected by a slight difference of pressure: by raising, for instance, the eudiometer tube a few inches above the level of the mercury. If this circumstance be not adverted to, unexpected explosions may occur.

One volume of protophosphuretted hydrogen gas absorbs in explosion 2 volumes of oxygen; and as the volume and a half of hydrogen which it contains requires $\frac{3}{4}$ of a volume of oxygen, the remaining $\frac{5}{4}$ of a volume of oxygen must go to the phosphorus. One volume of this phosphuretted gas may also combine with a volume and a half of oxygen, in which case phosphorous acid is formed with the $\frac{3}{4}$ of oxygen; whereas phosphoric acid was the former product with the $\frac{5}{4}$ of oxygen. Thus it would appear that the quantities of oxygen in phosphorous and phosphoric acids are to each other in the proportion of 3 to 5.

The perphosphuretted hydrogen procured by the action of phosphorus on milk of lime is spontaneously transformed by keeping over water to the protophosphuretted gas, without experiencing any alteration in its volume, simply by depositing phosphorus. The proportion of pure hydrogen which is always present in the perphosphuretted gas, and which of course remains mixed with the protophosphuretted, is easily ascertained by solution of sulphate of copper, which speedily absorbs the phosphuretted gas. Protophosphuretted gas thus prepared and examined was weighed with all the requisite precautions, and found to have a specific gravity of 1·214, air being 1000. Deducting from 1·214, $0.104\ (= 0.0694 + \frac{0\cdot0694}{2})$, being a volume and a half of hydrogen, the remainder 1.110 is the weight of phosphorus combined in this gas with the 0.104 of hydrogen. Now this is nearly the ratio of 10 to 1; whence, if we were to consider it a compound of one atom of each constituent, the prime equivalent of phosphorus would come out 10·78 on the hydrogen scale, or 1·4 on the oxygen.

M. Dumas, who adopts, with Berzelius, 0·0623 as the atom of hydrogen and the *radix* of atomic weights, supposes that in the protophosphuretted gas 6 atoms of hydrogen are combined with 1 of phosphorus, and infers the equivalent of phosphorus to be 402·3: for,

0·103 : 1·111 : : 37·4 (= 6 H) : 402·3.

The number of Berzelius is 392.3; therefore M. Dumas proposes to assume 400, the same as M. Dulong fixed on from the analyses of perchloride of phosphorus and phosphuret of copper.

2. *Perphosphuretted hydrogen.* This gas, obtained by acting on phosphorus in a retort, with a boiling-hot solution of caustic potash, consists very uniformly of $37\frac{1}{2}$ of perphosphuretted gas, mixed with $62\frac{1}{2}$ of pure hydrogen; or of 3 of the former to 5 of the latter. The phosphuretted gas is easily abstracted by

a solution of sulphate or nitrate of copper, or of corrosive sublimate.

Phosphuret of barytes disengages from distilled water a mixed gas, consisting of 43 of pure hydrogen and 57 of the perphosphuretted gas.

Phosphuret of lime, acted on by a little water over mercury, affords a similar mixture of gases, of which 87 are perphosphuretted, and 13 pure hydrogen. The same substance, acted on by strong muriatic acid, affords protophosphuretted hydrogen with deposition of phosphorus.

The perphosphuretted hydrogen obtained by boiling milk of lime on phosphorus is most variable in its proportion of intermingled hydrogen; this being near the beginning of the process about 30 per cent., and towards the end so high as 86. Yet all these gases are equally inflammable in the air.

Corrosive sublimate acts on the above mixed gases as it does on protophosphuretted hydrogen, and the hydrogen gas intermingled remains pure, without combining with the chlorine, at least at the heat of the alcohol flame. The action of the corrosive sublimate becomes energetic whenever it melts. The gas enlarges much in volume, and an orange-brown matter is produced. 76 parts of the mixed gas, containing 47½ of pure hydrogen and 28½ of perphosphuretted gas, afforded 86 of muriatic acid gas, containing 43 of hydrogen; whence perphosphuretted hydrogen evidently contains a volume and a half of pure hydrogen condensed into one volume, just like the protophosphuretted gas. The gas from phosphuret of lime and water, which is the purest that can be obtained, afforded also, by a similar treatment, 3 volumes of muriatic acid gas for every volume of the pure perphosphuretted hydrogen, indicating 1½ volume of pure hydrogen condensed in that single volume. The mixed gas from phosphuret of lime and water contains from 11 to 12 per cent. of uncombined hydrogen. Such mixed gas, heated by a spirit flame, in contact with fine iron or copper wire in a glass vessel, affords out of every volume of the perphosphuretted gas 1½ volume of pure hydrogen.

In order to effect the analysis of the perphosphuretted gas by oxygen, M. Dumas prepared absolutely pure carbonic acid. Some of it he mixed with its own volume of pure oxygen; and some with variable proportions of perphosphuretted hydrogen obtained from potash water and phosphorus. He then heated the mixture of carbonic acid gas and oxygen to 212° or 230° F. and introduced into it by bubble after bubble the mixture of carbonic acid and perphosphuretted hydrogen. With these precautions the experiment proceeded quietly; each bubble exploded on entering, however minute it might be. The light was faint and yellowish, without the lustre and vivacity observed in the ordinary combustions of this kind. When the operation was completed, he absorbed the carbonic acid, by moist fragments of caustic potash used in excess, and measured carefully the residuum, ascertaining the purity of the residual oxygen by explosion with hydrogen in the eudiometer over mercury. From the mean of these experiments, it results that 151 measures of perphosphuretted hydrogen, produced by the action of phosphorus on water of potash, consume 152 measures of oxygen; which may be regarded as the ratio of volume to volume. But this ratio, so simple in appearance, becomes somewhat complex when we come to consign to each of the bodies that the perphosphuretted hydrogen contains, the portion of oxygen due to it. In fact,

8 measures of the above gas = 5 hydrogen + 3 perphosphuretted hydrogen
8 oxygen = 2.5 + 5·5.

That is to say, 3 volumes of pure perphosphuretted hydrogen consume 5.5 volumes of oxygen; or 8 volumes consume 14·6 of oxygen; but

8 perphosp. hydr. pure = 12 hydr. + x phosphorus
14.6 oxygen = 6 + 8·6 phosphorus.

It is therefore evident, that, in the combustion of perphosphuretted hydrogen made under the above specified conditions, the hydrogen takes 2 volumes of oxygen and the phosphorus 3, to form water and phosphorous acid.

Perphosphuretted hydrogen gas, left to itself for some days, loses a third of the phosphorus that it contains, passing to the state of protophosphuretted hydrogen without any change of volume. When the perphosphuretted hydrogen is decomposed by the protoxide of azote, 8 volumes of the former consume 21 of the oxygen of the latter, 6 of which go to the 12 of hydrogen in the 8 of the perphosphuretted gas, and 15 to the phosphorus. In this case phosphoric acid is formed. Hence the same quantity of phosphorus takes either 9 or 15 volumes of oxygen; which gives the relation of 3 to 5 formerly noticed. The explosion of protoxide of azote and perphosphuretted hydrogen is extremely violent, and ought on this account to be performed on small quantities.

The specific gravity of perphosphuretted

hydrogen, determined by M. Dumas with much care, was found to be - 1·761, from which if we deduct 1½ vol. of hydr. 0·104,
we shall have the remainder = 1·657 for phosphorus. Here the proportion reduced to hydrogen as unity is 16 to 1. M. Dumas, supposing the hydrogen and the phosphorus to be combined in the ratio of 4 atoms of the former to 2 atoms of the latter, states the following proportion:

0.103 : 1·658 : : 24·87 (= 4 H) : 400·33;

which would be the atomic weight of phosphorus on the scale of Berzelius, where oxygen = 100, and hydrogen = 6·2175, or nearly $\frac{12·5}{2}$.

In this ingenious and elaborate research of M. Dumas, nothing is more striking than the difference between his specific gravities of these two gases, and the densities assigned to the same gases in Dr. Thomson's *First Principles*, where every number, by a process, of logical legerdemain, is made to tally with his atomic notions to the 3d or 4th place of decimals. Thus his gas (perphosphuretted hydrogen) from phosphuret of lime and water, has a sp. gr. of 0·90277; and is thus *made up*:—

Hydrogen,	1 volume	0·06944	or 1 atom	0·125
Phosphorus,	1 do.	0·83333	1	1·5 !
		0·90277		

Bihydroguret of phosphorus (protophosphuretted hydrogen of Dumas)

Hydrogen,	2 vol.	0·1388
Phosph.	1 do.	0.8333
		0·9721

Here this gas is made to contain two volumes of hydrogen, and have a density = 0·9722 !

Phosphorus and sulphur are capable of combining. They may be united by melting them together in a tube exhausted of air, or under water. In this last case, they must be used in small quantities; as, at the moment of their action, water is decomposed, sometimes with explosions. They unite in many proportions. The most fusible compound is that of one and a half of sulphur to two of phosphorus. This remains liquid at 40° Fahrenheit. When solid, its colour is yellowish-white. It is more combustible than phosphorus, and distils undecompounded at a strong heat. Had it consisted of 2 sulphur + 4 phosphorus, we should have had a definite compound of 1 prime of the first + 1 of the second constituent. This proportion forms the best composition for phosphoric fire-matches or bottles. A particle of it attached to a brimstone match, inflames when gently rubbed against a surface of cork or wood. An oxide made by heating phosphorus in a narrow-mouthed phial with an ignited wire answers the same purpose. The phial must be kept closely corked, otherwise phosphorous acid is speedily formed.

Phosphorus is soluble in oils, and communicates to them the property of appearing luminous in the dark. Alcohol and ether also dissolve it, but more sparingly.

When swallowed in the quantity of a grain it acts as a poison. Azote dissolves a little of it, and has its volume enlarged by about 1-40th. See EUDIOMETER.

PHOSPHORUS (of Baldwin). Ignited muriate of lime.

PHOSPHORUS (of Canton). Oyster shells calcined with sulphur.

PHOSPHORUS (of Bologna). See LIGHT. Sulphate of barytes.

PHOSPHURET. A compound of phosphorus with a combustible or metallic oxide.

PHOTICITE. A mixture of the silicate and carbo-silicate of manganese.

PHYLLADE, (INTERMEDIARY). The name given by the French geologists to graywacke slate.

PHYSALITE, OR PYROPHYSALITE. Colour greenish-white. Massive. In granular concretions. Splendent in the cleavage, which is perfect, and as in topaz. Fracture uneven. Translucent on the edges. As hard as topaz. Sp. gr. 3.451. It whitens with the blowpipe. Its constituents are, alumina 57·74, silica 34.36, fluoric acid 7·77. It is found in granite at Finbo, in Sweden. It is a sub-species of prismatic topaz.—*Jameson.*

PICNITE, OR PYCNITE. SCHORLITE.

PICROLITE. A massive mineral of a green or yellow colour, consisting chiefly of magnesia.

PICROMEL. The characteristic principle of bile. If sulphuric acid, diluted with five parts of water, be mixed with fresh bile, a yellow precipitate will fall. Heat the mixture, then leave it in repose, and decant off the clear part. What remains was formerly called resin of bile, but it is a greenish compound of sulphuric acid and picromel. Edulcorate it with water, and digest with carbonate of barytes. The picromel now liberated will dissolve in the water. On evaporating this solution, it is obtained in a solid state. Or by dissolving the green sulphate in alcohol, and digesting the solution over carbonate of potash till it cease to redden litmus paper, we obtain the picromel combined with alcohol.

It resembles inspissated bile. Its colour is greenish-yellow; its taste is intensely bitter at first, with a succeeding impression of sweetness. It is not affected by infusion of galls, but the salts of iron and subacetate of lead precipitate it from its aqueous solution. It affords no ammonia by its destructive distillation. Hence the absence of azote is inferred, and the peculiarity of picromel.

PICROTOXIA. The bitter and poisonous principle of *cocculus indicus*, the fruit of the *menispermum cocculus*. To the filtered decoction of these berries add acetate of lead, while any precipitate falls. Filter and evaporate the liquid cautiously to the consistence of an extract. Dissolve in alcohol of 0.817, and evaporate the solution to dryness. By repeating the solutions and evaporations, we at last obtain a substance equally soluble in water and alcohol. The colouring matter may be removed by agitating it with a little water. Crystals of pure picrotoxia now fall, which may be washed with a little alcohol.

The crystals are four-sided prisms, of a white colour, and intensely bitter taste. They are soluble in 25 times their weight of water, and are not precipitable by any known reagent. Alcohol, sp. gr. 0·810, dissolves one-third of its weight of picrotoxia. Pure sulphuric ether dissolves 2-5ths of its weight.

Strong sulphuric acid dissolves it, but not when much diluted. Nitric acid converts it into oxalic acid. It dissolves and neutralizes in acetic acid, and falls when this is saturated with an alkali. It may therefore be regarded as a vegeto-alkali itself. Aqueous potash dissolves it, without evolving any smell of ammonia. It acts as an intoxicating poison.

Sulphate of picrotoxia must be formed by dissolving picrotoxia in dilute sulphuric acid, for the strong acid chars and destroys it. The solution crystallizes on cooling. The sulphate of picrotoxia dissolves in 120 times its weight of boiling water. The solution gradually lets fall the salt in fine silky filaments disposed in bundles, and possessed of great beauty. When dry, it has a white colour, and feels elastic under the teeth, like plumose alum. It is composed of

Sulphuric acid,	9·99	5
Picrotoxia,	90·01	45
	100·00	

Nitrate of picrotoxia. Nitric acid, of the specific gravity 1.38, diluted with twice its weight of water, dissolves, when assisted by heat, the fourth of its weight of picrotoxia. When this solution is evaporated to one half, it becomes viscid, and on cooling is converted into a transparent mass, similar to a solution of gum-arabic. In this state the nitrate of picrotoxia is acid, and exceeding bitter. If it be still further dried in a temperature not exceeding 140°, it swells up, becomes opaque, and grows at last perfectly white and light, like calcined alum. If we keep it in this state, at a temperature below that of boiling water, adding a little water occasionally, the whole excess of acid exhales, and the taste becomes purely bitter. When this salt is washed in pure water, the acid is totally removed, and the picrotoxia is separated in the state of fine white plates.

Muriate of picrotoxia. Muriatic acid, of the specific gravity 1.145, has little action on picrotoxia. It dissolves it when assisted by heat, but does not become entirely saturated. Five parts of this acid, diluted with three times its weight of water, dissolve about one part of picrotoxia at a strong boiling temperature. The liquor, on cooling, is converted into a grayish crystalline mass, composed of confused crystals. When these crystal are well washed, they are almost destitute of taste, and feel elastic under the teeth. They dissolve in about 400 times their weight of boiling water, but are almost entirely deposited on cooling. The solubility is much increased by the presence of an excess of acid.

Acetate of picrotoxia. Acetic acid dissolves picrotoxia very well, and may be nearly saturated with it by the assistance of a boiling heat. On cooling, the acetate precipitates in well-defined prismatic needles. This acetate is soluble in 50 times its weight of boiling water. On cooling, it forms crystals of great beauty, light, without any acid smell, and much less bitter than picrotoxia itself. It is decomposed by nitric acid, which disengages the acetic acid. Dilute sulphuric acid has no marked action on it. It is not so poisonous as pure picrotoxia.—*Boullay, Ann. de Chimie.*

M. Casaseca denies the existence of menispermic acid, and of picrotoxia, as an alkaline base. It is merely a peculiar bitter vegetable principle as M. Boullay first announced.—*Ann. de Chimie*, xxx. 307.

PIMELITE. A variety of steatite, found at Kosemutz, in Silesia.

PINCHBECK. An alloy of copper, in which the proportion of zinc is greater than in brass.

PINEAL CONCRETIONS. Matter of a stony consistence is sometimes deposited in the substance of the pineal gland, formerly reckoned, from its position in the centre of the brain, to be the seat of the soul, the intellectual sanctuary. These concretions were proved by Dr. Wollaston to be phosphate of lime.

PINEY TALLOW. See TALLOW.

PINITE. Micarelle of Kirwan. Colour blackish-green. Massive, in lamellar concretions, and crystallized in an equiangular six-sided prism; in the same figure truncated or bevelled, and in a rectangular four-sided prism. Cleavage shining; lustre resinous. Fracture uneven. Opaque. Soft. Sectile; frangible, and not flexible. Feels somewhat greasy. Spec. grav. 2.95. Infusible. Its constituents are, silica 29.5, alumina 63.75, oxide of iron 6.75.—*Klaproth.* It is found in the granite of St. Michael's Mount, Cornwall; and in porphyry in Glen-Gloe and Blair-Gowrie.

PIPERINE. The active principle of pepper, a new vegetable principle extracted from black pepper by M. Pelletier. To obtain it, black pepper was digested repeatedly in alcohol, and the solution evaporated, until a fatty resinous matter was left. This, on being washed in warm water, became of a good green colour. It had a hot and burning taste; dissolved readily in alcohol, less so in ether. Concentrated sulphuric acid gave it a fine scarlet colour. The alcoholic solution after some days deposited crystals; which were purified by repeated crystallization in alcohol and ether. They then formed colourless four-sided prisms, with single inclined terminations. They have scarcely any taste. Boiling water dissolves a small portion; but not cold water. They are soluble in acetic acid: from which combination feather-formed crystals are obtained. This substance fuses at 212° Fahr. The fatty matter left after extracting the piperine, is solid at a temperature near 32°, but liquefies at a slight heat. It has an extremely bitter and acrid taste, is very slightly volatile, tending rather to decompose than to rise in vapour. It may be considered as composed of two oils: one volatile and balsamic; the other more fixed, and containing the acrimony of the pepper.

PISOLITE. Peastone.

PISTACITE. See EPIDOTE.

PITCH. See BITUMEN.

PITCH COAL. See COAL.

PITCH ORE. See ORES OF URANIUM.

PITCHSTONE. A sub-species of indivisible quartz. Colour green. Massive. Vitreo-resinous lustre. Feebly transparent on the edges. Fracture conchoidal. Semi-hard in a high degree. Rather easily frangible. Spec. grav. 2.2 to 2.3. It is fusible before the blowpipe. Its constituents are, silica 73, alumina 14.5, lime 1, oxide of iron 1, oxide of manganese 0.1, natron 1.75, water 8.5.—*Klaproth*. It occurs in veins that traverse granite. It is found in Arran, in Mull, Canna, Skye, and in the Townland of Newry, where it was first observed by Mr. Joy of Dublin.

PITCOAL. See COAL.

PITTIZITE. Pitchy iron ore. See ORES OF IRON.

PLANTS. See VEGETABLE KINGDOM.

PLASMA. Colour between grass-green and leek-green. In angular pieces. Glistening. Fracture conchoidal. Translucent. Hard. Brittle. Spec. grav. 2.553. Infusible. Its constituents are, silica 96.75, alumina 0.25, iron 0.5, loss 2.5.—*Klaproth*. It occurs in beds associated with common calcedony. It is found also among the ruins of Rome.

PLASTERS in surgery. Soap of oxide of lead, or compounds of resin and fat, either alone or combined with the former.

PLASTER OF PARIS. Gypsum.

PLATINA is one of the metals for the discovery of which we are indebted to modern times. Its ore has recently been found to contain, likewise, four new metals, palladium, iridium, osmium, and rhodium, which see, beside iron and chrome.

The crude platina is to be dissolved in nitro-muriatic acid, precipitated by muriate of ammonia, and exposed to a very violent heat. Then the acid and alkali are expelled, and the metal reduced in an agglutinated state, which is rendered more compact by pressure while red-hot.

Pure or refined platina is by much the heaviest body in nature. Its spec. grav. is 21.5. It is very malleable, though considerably harder than either gold or silver; and it hardens much under the hammer. Its colour on the touch-stone is not distinguishable from that of silver. Pure platina requires a very strong heat to melt it; but when urged by a white heat, its parts will adhere together by hammering. This property, which is distinguished by the name of welding, is peculiar to platina and iron, which resemble each other likewise in their infusibility.

Platina is not altered by exposure to air; neither is it acted upon by the most concentrated simple acids, even when boiling, or distilled from it.

The aqua regia best adapted to the solution of platina is composed of one part of the nitric and three of the muriatic acid. The solution does not take place with rapidity. A small quantity of nitric oxide is disengaged, the colour of the fluid becoming first yellow, and afterward of a deep reddish-brown, which, upon dilution with water, is found to be an intense yellow. This solution is very corrosive, and tinges animal matters of a blackish-brown colour: it affords crystals by evaporation.

Count Moussin Poushkin has given the following method of preparing malleable platina:—

Precipitate the platina from its solution by muriate of ammonia, and wash the precipitate with a little cold water. Reduce it in a convenient crucible to the well-known spongy metallic texture, which wash two or three times with boiling water, to carry off any portion of saline matter that may have escaped the action of the fire. Boil it for about half an hour in as much water, mixed with one-tenth part of muriatic acid, as will cover the mass to the depth of about half an inch, in a convenient glass vessel. This will carry off any quantity of iron that might still exist in the metal. Decant the acid water, and edulcorate, or strongly ignite the platina.

To one part of this metal take two parts of mercury, and amalgamate in a glass or porphyry mortar. This amalgamation takes place very readily. The proper method of conducting it is to take about two drachms of mercury to three drachms of platina, and amalgamate them together; and to this amalgam may be added alternate small quantities of platina and mercury, till the whole of the two metals is combined. Several pounds may be thus amalgamated in a few hours, and in the large way a proper mill, might shorten the operation.

As soon as the amalgam of mercury is made, compress it in tubes of wood, by the pressure of an iron screw upon a cylinder of wood adapted to the bore of the tube. This forces the superabundant mercury from the amalgam, and renders it solid. After two or three hours, burn upon the coals, or in a crucible lined with charcoal, the sheath in which the amalgam is contained, and urge the fire to a white heat; after which the platina may be taken out in a very solid state, fit to be forged.

Muriate of tin is so delicate a test of platina, that a single drop of the recent solution of tin in muriatic acid gives a bright red colour to a solution of muriate of platina, scarcely distinguishable from water.

If the muriatic solution of platina be agitated with ether, the ether will become impregnated with the metal. This ethereal solution is of a fine pale yellow, does not stain the skin, and is precipitable by ammonia.

If the nitro-muriatic solution of platina be precipitated by lime, and the precipitate digested in sulphuric acid, a sulphate of platinum will be formed. A subnitrate may be formed in the same manner. According to M. Chenevix, the insoluble sulphate contains 54.5 oxide of platinum, and 45.5 acid and water; the insoluble muriate, 70 of oxide; and the subnitrate, 89 of oxide; but the purity of the oxide of platinum in these is uncertain.

Platinum does not combine with sulphur directly, but is soluble by the alkaline sulphurets, and precipitated from its nitro-muriatic solution by sulphuretted hydrogen.

Pelletier united it with phosphorus, by projecting small bits of phosphorus on the metal heated to redness in a crucible; or exposing to a strong heat four parts each of platinum and concrete phosphoric acid with one of charcoal powder. The phosphuret of platinum is of a silvery-white, very brittle, and hard enough to strike fire with steel. It is more fusible than the metal itself, and a strong heat expels the phosphorus, whence Pelletier attempted to obtain pure platinum in this way. He found, however, that the last portions of phosphorus were expelled with too much difficulty.

Platinum unites with most other metals. Added in the proportion of one-twelfth to gold, it forms a yellowish-white metal, highly ductile, and tolerably elastic, so that Mr. Hatchett supposed it might be used with advantage for watch-springs, and other purposes. Its specific gravity was 19.013.

Platinum renders silver more hard, but its colour more dull.

Copper is much improved by alloying with platinum. From 1-6th to 1-25th, or even less, renders it of a golden colour, harder, susceptible of a finer polish, smooth-grained, and much less liable to rust.

Alloys of platinum with tin and lead are very apt to tarnish. See IRON.

From its hardness, infusibility, and difficulty of being acted upon by most agents, platinum is of great value for making various chemical vessels. These have, it is true, the inconvenience of being liable to erosion from the caustic alkalis and some of the neutral salts.

Platinum is now hammered in Paris into leaves of extreme thinness. By enclosing a wire of it in a little tube of silver, and drawing this through a steel plate in the usual way, Dr. Wollaston has succeeded in producing platinum wire not exceeding 1-3000th of an inch in diameter.

For some curious phenomena of its fusion, see BLOWPIPE; and for the singular action of hydrogen on spongy platinum, see HYDROGEN and EUDIOMETER. There are two oxides of platinum:—

1. When 100 parts of the protochloride or muriate of platinum are calcined, they leave 73.3 of metal; 26.7 of chlorine escape. Hence the prime equivalent of the metal would seem to be 12.3. When the above protochloride is treated with caustic potash, it is resolved into a black oxide of platinum and chloride of potassium. This oxide should consist of 12.3 metal + 1 oxygen. It is difficult to reconcile this statement of M. Berzelius with what he elsewhere says; for it would appear, that, by the same treatment, an oxide is obtained, containing 2 prime equivalents of oxygen—or 12 and a small fraction of platinum, united to 2 of oxygen. Considerable obscurity still hangs over the oxides of this metal.

An oxide of platinum has been described by Mr. E. Davy, which appears to be intermediate between the peroxide and protoxide of Berzelius. It was formed by boiling fulminating platinum in strong nitric acid, drying the product, and heating it to near ignition, then washing, first with water, and afterwards with a little potash. It has a dark iron-gray colour; is not affected by nitric, sulphuric, or phosphoric acid; and insoluble in muriatic and nitro-muriatic acids, unless when they are heated. It contains, by his analysis,

Platinum,	89·366	100
Oxygen,	10·634	11·9
	100·000	

2. The peroxide appears to contain three prime proportions. Berzelius obtained it by treating the muriate of platinum with sulphuric acid, at a distilling heat, and decomposing the sulphate by aqueous potash. The precipitated oxide is a yellowish-brown powder, easily reducible by a red heat to the metallic state.

According to Mr. E. Davy, the protochloride is soluble in water; while the bichloride is insoluble. If the common nitro-muriatic solution be cautiously dried, and heated to dull redness, washed with water, and again dried, we obtain a chloride, apparently consisting of

Platinum,	100, or	1 prime	11.86
Chlorine,	37.93	1	4.5?

It has a dull olive-brown or green colour; a harsh feel; and is destitute of taste and smell. It is not fusible by heat; nor is it altered by exposure to the atmosphere. At a full red heat the chlorine flies off, and platinum remains.

The oxide precipitated from a solution of this chloride by soda contains 15 or 16 of oxygen *per cent.* according to Vauquelin.

According to Mr. E. Davy, there are two phosphurets and three sulphurets of platinum. See his excellent memoir in the *Phil. Mag.* vol. xl.

The salts of platinum have the following general characters:—

1. Their solution in water is yellowish-brown.

2. Potash and ammonia determine the formation of small orange-coloured crystals.

3. Sulphuretted hydrogen throws down the metal in a black powder.

Ferroprussiate of potash, and infusion of galls, occasion no precipitate.

1. The sulphate of platinum may be obtained by passing a current of sulphuretted hydrogen gas through the nitro-muriatic solution. It should be washed and boiled once or twice with nitric acid, to ensure its entire conversion into sulphate. It has a brownish-black colour, and resembles the carbonaceous crust left when sugar is decomposed by heat. It is brittle, easily pulverized, and has the lustre nearly of crystallized blende. Its taste is acid, metallic, and somewhat caustic. It reddens litmus paper slightly. It is deliquescent, and soluble in water, alcohol, and ether, as well as in muriatic, nitric, and phosphoric acids. At a red heat it is resolved into metal. It appears from Mr. Davy's analysis to consist of—

		Theory.
Sulphuric acid,	26·3	27·58
Protoxide of platinum,	73·7	72·42.

This near coincidence is a verification of the analysis. A sulphate of potash and platinum is formed by neutralizing the sulphate with a solution of potash, and exposing the mixture for a little to a boiling heat. A granular substance resembling gunpowder is obtained. It is tasteless, insoluble in water, and possesses the lustre of blende. A soda-sulphate may be formed by a similar process; as also an ammonia-sulphate.

Fulminating platinum was discovered by Mr. Edmund Davy. Into a solution of the sulphate in water, aqueous ammonia is poured, and the precipitate which falls, being washed, is put into a matrass with potash-ley, and boiled for some time. It is then filtered, washed, and dried. A brown powder is obtained, lighter than fulminating gold, which is the fulminating platinum. It explodes violently when heated to 400°; but does not detonate by friction or percussion. It is a non-conductor of electricity. With sulphuric acid it forms a deep-coloured solution. Chlorine and muriatic gas decompose it. According to Mr. E. Davy, it consists of

Peroxide of platinum,	82·5	nearly 2	primes
Ammonia,	9·0	1	
Water,	8·5	2	

—See Salts.

PLATINUM ORE. See Ores of Platinum.

PLEONASTE. Ceylanite.

PLOMBGOMME, of the French, is the hydrous aluminate of lead.

PLUMBAGO. See Graphite.

POISONS. Substances which, when applied to living bodies, derange the vital functions, and produce death, by an action not mechanical. The study of their nature, mode of operation, and antidotes, has been called *toxicology*. Poisons have been arranged in six classes:

I.—*Corrosive* or *escharotic poisons.*

They are so named because they usually irritate, inflame, and corrode the animal texture with which they come into contact. Their action is in general more violent and formidable than that of the other poisons. The following list from Orfila contains the principal bodies of this class:—

1. *Mercurial preparations;* corrosive sublimate, red oxide of mercury; turbeth mineral, or yellow subsulphate of mercury; pernitrate of mercury; mercurial vapours.

2. *Arsenical preparations;* such as white oxide of arsenic, and its combinations with the bases, called arsenites; arsenic acid, and the arseniates; yellow and red sulphuret of arsenic; black oxide of arsenic, or fly-powder.

3. *Antimonial preparations;* such as tartar emetic, or cream tartrate of antimony; oxide of antimony; kermes mineral; muriate of antimony; and antimonial wine.

4. *Cupreous preparations;* such as verdigris; acetate of copper; the cupreous sulphate, nitrate, and muriate; ammoniacal copper; oxide of copper; cupreous soaps, or grease tainted with oxide of copper; and cupreous wines or vinegars.

5. *Muriate of tin.*

6. *Oxide and sulphate of zinc.*

7. *Nitrate of silver.*

8. *Muriate of gold.*

9. *Pearl-white*, or *the oxide of bismuth*, and the subnitrate of this metal.

10. *Concentrated acids;* sulphuric, nitric, phosphoric, muriatic, hydriodic, acetic, &c.

11. *Corrosive alkalis*, pure or subcarbonated potash, soda, and ammonia.

12. The *caustic earths*, lime and barytes.

13. *Muriate and carbonate of barytes.*

14. *Glass and enamel powder.*

15. *Cantharides.*

II.—*Astringent poisons.*

1. *Preparations of lead*, such as the acetate, carbonate, wines sweetened with lead, water impregnated with its oxide, food cooked in vessels containing lead, syrups clarified with subacetate of lead, plumbean vapours.

III.—*Acrid poisons.*

1. The *gases;* chlorine, muriatic acid, sulphurous acid, nitrous gas, and nitro-muriatic vapours.

2. Jatropha manihot, the fresh root, and its juice, from which cassava is made.

3. *The Indian ricinus*, or Molucca wood.

4. *Scammony.* 5. Gamboge. 6. Seeds of *palma Christi.* 7. Elaterium. 8. Colocynth. 9. White hellebore root. 10. Black hellebore root. 11. Seeds of stavesacre. 12. The wood and fruit of the *ahovaï* of Brasil. 13. Rhododendron chrysanthum. 14. Bulbs of *colchicum*, gathered in summer and autumn. 15. The milky juice of the convolvulus arvensis. 16. Asclepias. 17. Œnanthe fistulosa and crocata. 18. Some species of *clematis.* 19. Anemone pulsatilla. 20. Root of wolf's-bane. 21. Fresh roots of Arum maculatum. 22. Berries and bark of Daphne Mezereum. 23. The plant and emanations of the rhus toxicodendron. 24. Euphorbia officinalis. 25. Several species of ranunculus, particularly the aquatilis. 26. Nitre, in a large dose. 27. Some muscles and other shell-fish.

IV. *Narcotic and stupefying poisons.*

1. The *gases ;* hydrogen, azote, and oxide of azote.

2. Poppy and opium.

3. The roots of the solanum somniferum; berries and leaves of the solanum nigrum; those of the morel with yellow fruit. 4. The roots and leaves of the atropa mandragora. 5. Datura stramonium. 6. Hyosciamus, or henbane. 7. Lactuca virosa. 8. Paris quadrifolia, or herb Paris. 9. Laurocerasus, or bay laurel and prussic acid. 10. Berries of the yew tree. 11. Ervum ervilia; the seeds. 12. The seeds of lathyrus cicera. 13. Distilled water of bitter almonds. 14. The effluvia of many of the above plants.

V.—*Narcotico-acrid poisons.*

1. Carbonic acid; the gas of charcoal stoves and fermenting liquors. 2. The manchineel. 3. Faba Sancti Ignatii. 4. The exhalations and juice of the poison-tree of Macassar, or Upas-Antiar. 5. The ticunas. 6. Certain species of strychnos. 7. The whole plant, Lauro-cerasus. 8. Belladonna, or deadly nightshade. 9. Tobacco. 10. Roots of white bryony. 11. Roots of the Chærophyllum silvestre. 12. Conium maculatum, or spotted hemlock. 13. Æthusa cynapium. 14. Cicuta virosa. 15. Anagalis arvensis. 16. Mercurialis perennis. 17. Digitalis purpurea. 18. The distilled waters and oils of some of the above plants. 19. The odorant principle of some of them. 20. Woorara of Guiana. 21. Camphor. 22. Cocculus Indicus. 23. Several mushrooms; see AGARICUS, and BOLETUS. 24. Secale cornutum. 25. Lolium temulentum. 26. Sium latifolium. 27. Coriaria myrtifolia.

VI.—*Septic or putrescent poisons.*

1. Sulphuretted hydrogen. 2. Putrid effluvia of animal bodies. 3. Contagious effluvia, or fomites and miasmata; see MIASMATA. 4. Venomous animals; the viper, rattlesnake, scorpion, mad dog, &c:

I regret that the limits of this work preclude me from introducing a systematic view of the mode of action of the principal substances in the above catalogue. Under *Antimony*, *Arsenic*, *Copper*, *Lead*, *Mercury*, *Silver*, pretty copious details are given of the poisonous effects of their preparations, and of the best methods of counteracting them.

Antidote for vegetable poisons. M. Drapiez has ascertained, by numerous experiments, that the fruit of the *feuille cordifolia* is a powerful antidote against vegetable poisons. He poisoned dogs with the rhus toxicodendron, hemlock, and nux vomica; and all those which were left to the effects of the poison died, but those to which the above fruit was administered recovered completely, after a short illness. To see whether the antidote would act in the same way, applied externally to wounds into which vegetable poisons had been introduced, he took two arrows, which had been dipped into the juice of the *manchenille*, and slightly wounded with them two cats; to one of these wounds he applied a poultice, composed of the fruit of the *feuillea cordifolia*, while the other was left without any application. The former suffered no inconvenience, except from the pain of the wound, which speedily healed; while the other, in a short time, fell into convulsions, and died. This fruit loses these valuable virtues, if kept two years after it is gathered.

Dr. Chisholm states, that the juice of the sugar-cane is the best antidote for arsenic.

Dr. Lyman Spalding of New-York announces in a small pamphlet, that for above these fifty years, the *Scutellaria Lateriflora* has proved to be an infallible means for the prevention and cure of the hydrophobia, after the bite of rabid animals. It is better applied as a dry powder than fresh. According to the testimonies of several American physicians, this plant, not yet received as a remedy into any European *Materia Medica*, afforded perfect relief in above a thousand cases, as well in the human species as in the brute creation, (dogs, swine, and oxen).—*Phil. Mag.* lvi. p. 151.

POLISHING-SLATE. See CLAY.

POLLEN. The powdery matter evolved from the *antheræ* of flowers. That of the date seems, from the experiments of Fourcroy and

Vauquelin, to approach in its constitution to animal substances; that of the hazel-nut contains tannin, resin, much gluten, and a little fibrin; and that of the tulip yielded to Grotthus the following constituents in 26 parts:

Vegetable albumen, . .	20·25
Malate of lime, with trace of malate of magnesia, ...	3·50
Malic acid, ...	1·00
Malate of ammonia, .	1.25
Colouring matter, .	
Saltpetre? . .	
	26·00

The principle in pollen, intermediate between gluten and albumen, has been named by Dr. John, *Pollenin*.

It is yellow, without taste and smell; insoluble in water, alcohol, ether, fat, and volatile oils, and petroleum.

It burns with flame. On exposure to air, it assumes the smell and taste of cheese, and soon becomes putrid with disengagement of ammonia.

POLYCHROITE. The colouring matter of saffron.

POLYMIGNITE. A new mineral found sometimes in the zirconian sienite of Fredrickswärns. It is black, brilliant, and crystallized in small prisms, long, thin, with a rectangle, the edges of which are commonly replaced by one or several planes. Sp. gr. 4·806. It scratches glass, but cannot be scratched by steel. Fracture conchoidal, without indications of cleavage. The surface of the crystals has vivid lustre, almost metallic. The fracture also resembles the surface, possessing a brilliancy far beyond what is common in minerals. At the blowpipe it suffers no change. With borax, it melts easily, and forms a glass coloured with iron. With more borax, it becomes opaque and of an orange colour. Its composition is extraordinary:

Titanic acid, . . .	46·3
Zirconia, . . .	14·4
Oxide of iron, . . .	12·2
Lime, ...	4·2
Oxide of manganese, . .	2·7
Oxide of cerium, . .	5·0
Yttria, ...	11·5
Traces of magnesia, potash, silica, oxide of tin,	
	96·3.

—*Berzelius; Annales de Chim.* xxxi. 465.

POLYHALLITE. A mineral in masses of a fibrous texture. Sp. gr. 277. Pearly lustre. Its constituents are, hydrous sulphate of lime 28·25; anhydrous sulphate 22·42; anhydrous sulphate of magnesia 20·03; sulph. of potash 27·7; muriate of soda 0·19; red oxide of iron 0·34. It occurs at Ischel in Upper Austria.

POMPHOLIX. White oxide of zinc.

PONDEROUS SPAR. See HEAVY SPAR.

PORCELAIN EARTH. See CLAY.

PORCELAIN is the most beautiful and the finest of all earthen wares.

The art of making porcelain is one of those in which Europe was long excelled by oriental nations. The first porcelain that was seen in Europe was brought from Japan and China. The whiteness, transparency, fineness, neatness, elegance, and even the magnificence of this pottery, which soon became the ornament of sumptuous tables, did not fail to excite the admiration and industry of Europeans.

Father Entrecolles, missionary at China, sent home a summary description of the process by which the inhabitants of that country make their porcelain, and also a small quantity of the materials which they employ in its composition. He said, that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them petuntse, which they carefully grind to a very fine powder; and the other, called by them kaolin, is a white earthy substance, which they mix intimately with the ground petuntse.

Reaumur examined both these matters; and having exposed them separately to a violent fire, he discovered that the petuntse had fused without addition, and that the kaolin had given no sign of fusibility. He afterward mixed these matters, and formed cakes of them, which, by baking, were converted into porcelain similar to that of China. See KAOLIN, PETUNTSE, and POTTERY.

PORCELAIN OF REAUMUR. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky colour, semitransparent, so hard as to strike fire with steel, infusible, and of a fibrous grain, by means of cementation. The process, which he published, is not difficult. Common glass, such as that of which wine bottles are made, succeeds best. The glass vessel which is to be converted into porcelain is to be enclosed in a baked earthen case or seggar. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthenware; after which the glass vessel will be found transformed into such a matter as has been described.

PORPHYRY is a compound rock, having a basis, in which the other contemporaneous constituent parts are imbedded. The base is sometimes clay-stone, sometimes hornstone, sometimes compact felspar; or pitchstone, pearlstone, and obsidian. The imbedded parts are most commonly felspar and quartz, which are usually crystallized more or less perfectly, and hence they appear sometimes granular. According to Werner, there are two distinct porphyry formations; the oldest occurs in gneiss, in beds of great magnitude; and also in mica-slate and clay-slate. Between Blair in Athole and Dalnacardoch, there is a very fine example of a bed of porphyry-slate in mica. The second porphyry formation is much more widely extended. It consists principally of clay porphyry, while the former consists chiefly of hornstone porphyry and felspar porphyry.

It sometimes contains considerable repositories of ore, in veins. Gold, silver, lead, tin, copper, iron, and manganese occur in it; but chiefly in the newer porphyry, as happens with the Hungarian mines. It occurs in Arran, and in Perthshire between Dalnacardoch and Tummel-bridge.

PORTLAND STONE. A compact sandstone from the Isle of Portland. The cement is calcareous.

POTASH, commonly called the vegetable alkali, because it is obtained in an impure state by the incineration of vegetables. It is the hydrated protoxide of potassium.

Table of the saline product of one thousand lbs. of ashes of the following vegetables:—

	Saline products.	
Stalks of Turkey wheat or maise,	198 lbs.	
Stalks of sun-flower,	349	
Vine branches,	162·6	
Elm,	166	
Box,	78	
Sallow,	102	
Oak,	111	
Aspen,	61	
Beech,	219	
Fir,	132	
Fern cut in August,	116	or 125, according to Wildenheim.
Wormwood,	748	
Fumitory,	360	
Heath,	115	Wildenheim.

On these tables Kirwan makes the following remarks:—

1. That in general weeds yield more ashes, and their ashes much more salt, than woods; and that consequently, as to salts of the vegetable alkali kind, as potash, pearl-ash, cashup, &c. neither America, Trieste, nor the northern countries, have any advantage over Ireland.

2. That of all weeds fumitory produces most salt, and next to it wormwood. But if we attend only to the quantity of salt in a given weight of ashes, the ashes of wormwood contain most. Trifolium fibrinum also produces more ashes and salt than fern.

The process for obtaining pot and pearl-ash is given by Kirwan, as follows:—

1. The weeds should be cut just before they seed, then spread, well dried, and gathered clean.

2. They should be burned within doors on a grate, and the ashes laid in a chest as fast as they are produced. If any charcoal be visible, it should be picked out, and thrown back into the fire. If the weeds be moist, much coal will be found. A close smothered fire, which has been recommended by some, is very prejudicial.

3. They should be lixiviated with twelve times their weight of boiling water. A drop of the solution of corrosive sublimate will immediately discover when the water ceases to take up any more alkali. The earthy matter that remains is said to be a good manure for clayey soils.

4. The ley thus formed should be evaporated to dryness in iron pans. Two or three at least of these should be used, and the ley, as fast as it is concreted, passed from the one to the other. Thus, much time is saved, as weak leys evaporate more quickly than the stronger. The salt thus produced is of a dark colour, and contains much extractive matter, and being formed in iron pots is called potash.

5. This salt should then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water dissipated: hence it generally loses from ten to fifteen per cent. of its weight. Particular care should be taken to prevent its melting, as the extractive matter would not then be perfectly consumed, and the alkali would form such a union with the earthy parts as could not easily be dissolved. Kirwan adds this caution, because Dr. Lewis and Mr. Dossie have inadvertently directed the contrary. This salt thus refined is called pearl-ash, and must be the same as the Dantzic pearl-ash.

To obtain this alkali pure, Berthollet recommends, to evaporate a solution of potash, made caustic by boiling with quicklime, till it becomes of a thickish consistence; to add about an equal weight of alcohol, and let the mixture stand some time in a close vessel. Some solid matter, partly crystallized, will collect at the bottom; above this will be a small quantity of a dark-coloured fluid; and on the top another lighter. The latter, separated by decantation, is to be evaporated quickly in a silver basin in a sand-heat. Glass, or almost any other metal, would be corroded by the potash. Before the evaporation has been carried far, the solution is to be removed from the fire, and suffered to stand at rest; when it will again separate into two fluids. The lighter, being poured off, is again to be evaporated with a quick heat; and on standing a day or two in a close vessel, it will deposit transparent crystals of pure potash. If the liquor be evaporated to a pellicle, the potash will concrete without regular crystallization. In both cases a high-coloured liquor is separated, which is to be poured off; and the potash must be kept carefully secluded from air.

A perfectly pure solution of potash will remain transparent on the addition of lime-water, show no effervescence with dilute sulphuric acid, and not give any precipitate on blowing air from the lungs through it by means of a tube.

Pure potash for experimental purposes may most easily be obtained by igniting cream of tartar in a crucible, dissolving the residue in water, filtering, boiling with a quantity of quicklime, and after subsidence, decanting the clear liquid, and evaporating in a loosely covered silver capsule, till it flows like oil, and then pouring it out on a clean iron plate. A solid white cake of pure hydrate of potash is thus obtained, without the agency of alcohol. It must be immediately broken into fragments, and kept in a well-stoppered phial.

As 100 parts of subcarbonate of potash are equivalent to about 70 of pure concentrated oil of vitriol, if into a measure tube, graduated into 100 equal parts, we introduce the 70 grains of acid, and fill up the remaining space with water, then we have an alkalimeter for estimating the value of commercial pearl-ashes, which, if pure, will require for 100 grains one hundred divisions of the liquid to neutralize them. If they contain only 60 per cent. of genuine subcarbonate, then 100 grains will require only 60 divisions, and so on. When the alkalimeter indications are required in pure or absolute potash, such as constitutes the basis of nitre, then we must use 102 grains of pure oil of vitriol, along with the requisite bulk of water to fill up the volume of the graduated tube.

The hydrate of potash, as obtained by the preceding process, is solid, white, and extremely caustic; in minute quantities, changing the purple of violets and cabbage to a green, reddened litmus to purple, and yellow turmeric to a reddish-brown. It rapidly attracts humidity from the air, passing into the oil of tartar *per deliquium* of the chemists; a name, however, also given to the deliquesced subcarbonate. Charcoal applied to the hydrate of potash at a cherry-red heat gives birth to carburetted hydrogen, and an alkaline subcarbonate; but at a heat bordering on whiteness, carburetted hydrogen, carbonous oxide, and potassium, are formed. Several metals decompose the hydrate of potash, by the aid of heat; particularly potassium, sodium, and iron. The fused hydrate of potash consists of 6 protoxide of potassium + 1.125 water = 7.125, which number represents the compound prime equivalent. It is used in surgery, as the potential cautery for forming eschars; and it was formerly employed in medicine diluted with broths as a lithontriptic. In chemistry, it is very extensively employed, both in manufactures and as a reagent in analysis. It is the basis of all the common soft soaps. The oxides of the following metals are soluble in aqueous potash:—Lead, tin, nickel, arsenic, cobalt, manganese, zinc, antimony, tellurium, tungsten, molybdenum. For the sulphuret, see SULPHUR.

POTASSIUM. If a thin piece of solid hydrate of potash be placed between two discs of platinum, connected with the extremities of a voltaic apparatus of 200 double plates, four inches square, it will soon undergo fusion; oxygen will separate at the positive surface, and small metallic globules will appear at the negative surface. These form the marvellous substance potassium, first exhibited to the world by Sir H. Davy, early in October 1807.

If iron turnings be heated to whiteness in a curved gun-barrel, and potash be melted and made slowly to come in contact with the turnings, air being excluded, potassium will be formed, and will collect in the cool part of the tube. This method of procuring it was discovered by MM. Gay Lussac and Thenard in 1808. It may likewise be produced by igniting potash with charcoal, as M. Curaudau showed the same year.

M. Brunner, by acting on calcined tartar in a bottle of wrought iron, has succeeded in obtaining potassium at a comparatively moderate heat. The bottle is spheroidal, about half an inch in thickness, and capable of holding about a pint of water; a bent gun-barrel of 10 or 12 inches in length screws into the mouth of the bottle. The bottle well luted over with fire-clay, is set in a strong air furnace, so as the tube may dip down externally beneath the surface of naphtha contained in a cylindric copper vessel, standing in a tub containing ice and water. The top of the naphtha vessel has a cover fixed on it, pierced with a hole to receive the end of the gun-barrel; and from the side of the upper part of the vessel, a small tube goes off at right angles to let the air and vapours escape. It is advantageous to mix a little ground charcoal with the tartar previously calcined in a covered vessel, in the same iron bottle for example. Nearly 300 grains of potassium have been procured by this apparatus from 24 ounces of crude tartar.—*Biblioth. Universelle*, xxii. 36.

Potassium is possessed of very extraordinary properties. It is lighter than water; its sp. gr. being 0.865 to water 1.0. At common temperatures it is solid, soft, and easily moulded by the fingers. At 150° F. it fuses, and in a heat a little below redness it rises in vapour. It is perfectly opaque. When newly cut, its colour is splendent white, like that of silver, but it rapidly tarnishes in the air. To preserve it unchanged, we must enclose it in a small phial, with pure naphtha. It conducts electricity like the common metals. When thrown upon water, it acts with great violence, and swims upon the surface, burning with a beautiful light of a red colour, mixed with violet. The water becomes a solution of pure potash. When moderately heated in the air, it inflames, burns with a red light, and throws off alkaline fumes. Placed in chlorine, it spontaneously burns with great brilliancy.

On all fluid bodies which contain water, or much oxygen or chlorine, it readily acts; and in its general powers of chemical combination, says its illustrious discoverer, potassium may be compared to the alkahest, or universal solvent, imagined by the alchemists.

Potassium combines with oxygen in different proportions. When potassium is gently heated in common air or in oxygen, the result of its combustion is an orange-coloured fusible substance. For every grain of the metal consumed, about $1\frac{7}{10}$ cubic inches of oxygen are condensed. To make the experiment accurately, the metal should be burned in a tray of platina covered with a coating of fused muriate of potash.

The substance procured by the combustion of potassium at a low temperature was first observed in October, 1807, by Sir H. Davy, who supposed it to be the protoxide; but MM. Gay Lussac and Thenard, in 1810, showed that it was in reality the deutoxide or peroxide. When it is thrown into water, oxygen is evolved, and a solution of the protoxide results, constituting common aqueous potash. When it is fused, and brought in contact with combustible bodies, they burn vividly, by the excess of its oxygen. If it be heated in carbonic acid, oxygen is disengaged, and common subcarbonate of potash is formed.

When it is heated very strongly upon platina, oxygen gas is expelled from it, and there remains a difficultly fusible substance of a gray colour, vitreous fracture, soluble in water without effervescence, but with much heat. Aqueous potash is then produced. The above ignited solid is protoxide of potassium, which becomes pure potash by combination with the equivalent quantity of water. When we produce potassium with ignited iron-turnings and potash, much hydrogen is disengaged from the water of the hydrate, while the iron becomes oxidized from the residuary oxygen. By heating together pure hydrate of potash and boracic acid, Sir H. Davy obtained from 17 to 18 of water from 100 parts of the solid alkali.

By acting on potassium with a very small quantity of water, or by heating potassium with fused potash, the protoxide may also be obtained. The proportion of oxygen in the protoxide is determined by the action of potassium upon water. 8 grains of potassium produce from water about 9½ cubic inches of hydrogen; and for these the metal must have fixed 4¾ cubic inches of oxygen. But as 100 cubic inches of oxygen weigh 33.9 gr. 4¾ will weigh 1.61. Thus, 9.61 gr. of the protoxide will contain 8 of metal; and 100 will contain 83.25 metal + 16.75 oxygen. From these data, the prime of potassium comes out 4.969; and that of the protoxide 5.969. Sir H. Davy adopts the number 75 for potassium, corresponding to 50 on the oxygen scale.

When potassium is heated strongly in a small quantity of common air, the oxygen of which is not sufficient for its conversion into potash, a substance is formed of a grayish colour, which, when thrown into water, effervesces without taking fire. It is doubtful whether it be a mixture of the protoxide and potassium, or a combination of potassium with a smaller proportion of oxygen than exists in the protoxide. In this case it would be a suboxide, consisting of 2 primes of potassium = 10 + 1 of oxygen = 11.

When thin pieces of potassium are introduced into chlorine, the inflammation is very vivid; and when potassium is made to act on chloride of sulphur, there is an explosion. The attraction of chlorine for potassium is much stronger than the attraction of oxygen for the metal. Both of the oxides of potassium are immediately decomposed by chlorine, with the formation of a fixed chloride, and the extrication of oxygen.

The combination of potassium and chlorine is the substance which has been improperly called muriate of potash, and which, in common cases, is formed, by causing liquid muriatic acid to saturate solution of potash, and then evaporating the liquid to dryness and igniting the solid residuum. The hydrogen of the acid here unites to the oxygen of the alkali, forming water, which is exhaled; while the remaining chlorine and potassium combine. It consists of 5 potassium + 4.5 chlorine.

Potassium combines with hydrogen, to form potassuretted hydrogen, a spontaneously inflammable gas, which comes over occasionally in the production of potassium by the gun-barrel experiment. MM. Gay Lussac and Thenard describe also a solid compound of the same two ingredients, which they call a hydruret of potassium. It is formed by heating the metal a long while in the gas, at a temperature just under ignition. They describe it as a grayish solid, giving out its hydrogen on contact with mercury.

When potassium and sulphur are heated together, they combine with great energy, with disengagement of heat and light even *in vacuo*. The resulting sulphuret of potassium is of a dark gray colour. It acts with great energy on water, producing sulphuretted hydrogen, and burns brilliantly when heated in the air, becoming sulphate of potash. It consists of 2 sulphur + 5 potassium, by Sir H. Davy's experiments. Potassium has so strong an attraction for sulphur, that it rapidly separates it from hydrogen. If the potassium be heated in the sulphuretted gas, it takes fire and burns with great brilliancy; sulphuret of potassium is formed, and pure hydrogen is set free.

Potassium and phosphorus enter into union with the evolution of light; but the mutual action is feebler than in the preceding compound. The phosphuret of potassium, in its common form, is a substance of a dark chocolate colour, but when heated with potassium in great excess, it becomes of a deep gray colour, with considerable lustre. Hence it is probable, that phosphorus and potassium are capable of combining in two proportions. The phosphuret of potassium burns with great brilliancy, when exposed to air, and when thrown into water produces an explosion, in consequence of the immediate disengagement of phosphuretted hydrogen.

Charcoal which has been strongly heated in contact with potassium effervesces in water, rendering it alkaline, though the charcoal may be previously exposed to a temperature at which potassium is volatilized. Hence, there is probably a compound of the two formed by a feeble attraction.

Of all known substances, potassium is that which has the strongest attraction for oxygen; and it produces such a condensation of it, that the oxides of potassium are denser than the metal itself. Potassium has been skilfully used by Sir H. Davy and MM. Gay Lussac and Thenard, for detecting the presence of oxygen in bodies. A number of substances, undecomposable by other chemical agents, are readily decomposed by this substance.—*Elements of Chemical Phil. by Sir H. Davy.*

POTASSIUM (IODIDE OF). See ACID (HYDRIODIC).

POTTERY. The art of making pottery is intimately connected with chemistry, not only from the great use made of earthen vessels by chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry.

The process of manufacturing stoneware, according to Dr. Watson, is as follows:

Tobacco-pipe clay from Dorsetshire is beaten much in water. By this process, the finer parts of the clay remain suspended in the water, while the coarser sand and other impurities fall to the bottom. The thick liquid, consisting of water and the finer parts of the clay, is farther purified by passing it through hair and lawn sieves, of different degrees of fineness. After this, the liquid is mixed (in various proportions for various wares), with another liquor, of as nearly as may be the same density, and consisting of flints calcined, ground, and suspended in water. The mixture is then dried in a kiln; and being afterward beaten to a proper temper, it becomes fit for being formed at the wheel into dishes, plates, bowls, &c. When this ware is to be put into the furnace to be baked, the several pieces of it are placed in the cases made of clay, called seggars, which are piled one upon another, in the dome of the furnace. A fire is then lighted; and when the ware is brought to a proper temper, which happens in about forty-eight hours, it is glazed by common salt. The salt is thrown into the furnace, through holes in the upper part of it, by the heat of which it is instantly converted into a thick vapour; which, circulating through the furnace, enters the seggar through holes made in its side, (the top being covered to prevent the salt from falling on the ware); and attaching itself to the surface of the ware, it forms that vitreous coat upon the surface which is called its glaze.

The yellow or queen's-ware is made of the same materials as the flint-ware; but the proportion in which the materials are mixed is not the same, nor is the ware glazed in the same way. The flint-ware is generally made of four measures of liquid flint, and of eighteen of liquid clay. The yellow ware has a greater proportion of clay in it. In some manufactories they mix 20, and in others 24 measures of clay, with 4 of flint. These proportions, if estimated by the weight of the materials, would probably give for the flint-ware about 3 cwt. of clay to 1 cwt. of flint, and for the yellow ware somewhat more clay. The proportion, however, for both sorts of ware depends very much upon the nature of the clay, which is very variable even in the same pit. Hence a previous trial must be made of the quality of the clay, by burning a kiln of the ware. If there be too much flint mixed with the clay, the ware, when exposed to the air after burning, is apt to crack; and if there be too little, the ware will not receive the proper glaze from the circulation of the salt vapour.

This glaze, even when it is most perfect, is in appearance less beautiful than the glaze on the yellow ware.

The yellow glaze is made by mixing together in water, till it becomes as thick as cream, 112 lb. of white lead, 24 lb. of ground flint, and 6 lb. of ground flint-glass. Some manufactories leave out the glass, and mix only 80lb. of white lead with 20lb. of ground flint; and others doubtless observe different rules, of which it is very difficult to obtain an account.

The ware before it is glazed is baked in the fire. By this means it acquires the property of strongly imbibing moisture. It is therefore dipped in the liquid glaze, and suddenly taken out: the glaze is imbibed into its pores, and the ware presently becomes dry. It is then exposed a second time to the fire, by which means the glase it has imbibed is melted, and a thin glassy coat is formed upon its surface. The colour of this coat is more or less yellow, according as a greater or less proportion of lead has been used. The lead is principally instrumental in producing the glaze, as well as in giving it the yellow colour; for lead, of all the substances hitherto known, has the greatest power of promoting the vitrification of the substances with which it is mixed. The flint serves to give a consistence to the lead during the time of its vitrification, and to hinder it from becoming too fluid, and running down the sides of the ware, and thereby leaving them unglazed.

The yellowish colour which lead gives when vitrified with flints, may be wholly changed by very small additions of other mineral substances. Thus, to give one instance, the beautiful black glase, which is fixed on one sort of the ware made at Nottingham, is composed of 21 parts by weight of white lead, of 5 of powdered flints, and of 3 of manganese. The queen's-ware at present is much whiter than formerly.

The coarse stoneware made at Bristol consists of tobacco-pipe clay and sand, and is glazed by the vapour of salt, like Staffordshire flint-ware; but it is far inferior to it in beauty.

POTENTIAL CAUTERY. Caustic potash.

POTSTONE, or LAPIS OLLARIS. Colour greenish-gray. Massive, and in granular concretions. Glistening. Fracture curved, foliated. Translucent on the edges. Streak white. Soft. Sectile. Feels greasy. Somewhat tough. Sp. gr. 2·8. Its constituents are, silica 39, magnesia 16, oxide of iron 10, carbonic acid 20, water 10. It occurs in thick beds in primitive slate. It is found abundantly on the shores of the lake Como in Lombardy. It is fashioned into culinary vessels in Greenland. It is a subspecies of the rhomboidal mica of Professor Jameson.

POWDER OF ALGOROTH. The white oxide of antimony, thrown down from the muriate, by water.

PRASE. Colour leek-green. Massive, seldom crystallized. Its forms are, the six-sided prism, and the six-sided pyramid. Lustre shining. Fracture conchoidal. Translucent. Hard. Tough. Sp. gr. 2.67. Its constituents are, silica 98.5, alumina, with magnesia, 0·5, and oxide of iron 1.—*Bucholz*. It occurs in mineral beds composed of magnetic ironstone, galena, &c. It is found in the island of Bute, and in Borrodale.

PRECIPITANTS. See METALS, and MINERAL WATERS.

PRECIPITATE, AND PRECIPITATION. When a body dissolved in a fluid is either in whole or in part made to separate and fall down in the concrete state, this falling down is called precipitation, and the matter thus separated is called a precipitate. See WATERS (MINERAL), and METALS.

PRECIPITATE, *per se*. Red oxide of mercury, by heat.

PREHNITE. Prismatic prehnite; of which there are two sub-species, the foliated and the fibrous.

1. *Foliated*. Colour apple-green. Massive in distinct concretions, and sometimes crystallized. The primitive form is an oblique four-sided prism of 103° and 77°. The secondary forms are, an oblique four-sided table, an irregular eight-sided table, an irregular six-sided table, and a broad rectangular four-sided prism. Shining. Fracture fine-grained uneven. Translucent. Hardness from felspar to quartz. Easily frangible. Sp. gr. 2.8 to 3.0. It melts with intumescence into a pale-green or yellow glass. It does not gelatinise with acids. Its constituents are, silica 43·83, alumina 30·33, lime 18·33, oxide of iron 5·66, water 1·83.—*Klaproth*. It occurs in France, in the Alps of Savoy, and in the Tyrol. It is said to become electric by heating. Beautiful varieties are found in the interior of Southern Africa.

2. *Fibrous Prehnite*. Colour siskin-green. Massive, in distinct concretions, and crystallized in acicular four-sided prisms. Glistening, pearly. Translucent. Easily frangible. Sp. gr. 2·89. It melts into a vesicular enamel. It becomes electric by heating. Its constituents are, silica 42.5, alumina 28·5, lime 20·44, natron and potash 0·75, oxide of iron 3, water 2.—*Laugier*. It occurs in veins and cavities in trap-rocks near Beith in Ayrshire, Bishoptown in Renfrewshire, at Hartfield near Paisley, and near Frisky-hall, Old Kilpatrick: in the trap-rocks round Edinburgh, &c.

PRINCE'S METAL. A species of copper alloy, in which the proportion of zinc is more considerable than in brass.

PROSTATE CONCRETIONS. See CALCULI.

PRUSSIAN ALKALI. See ACID (FERROPRUSSIC).

PRUSSIAN BLUE. See IRON and the above ACID.

PRUSSIC ACID. See ACID (PRUSSIC).

PSEUDOLITE. A mineral having a close affinity to the pseudomorphous crystals of steatite. *Annals of Phil.* x. 314.

PULMONARY CONCRETIONS, consist of carbonate of lime, united to a membranous or animal matter. By Mr. Compton's analysis, *Phil. Mag.* vol. xiii. 100 parts contain,

Carbonate of lime,	82
Animal matter and water,	18

Disease proceeding from this cause, (and I believe it to be a frequent prelude and concomitant of ulcerated lungs), might be probably benefited by the regular inhalation of aqueous vapour mixed with that of acetic acid or vinegar.

PUMICE. A mineral of which there are three kinds,—the glassy, common, and porphyritic.

1. *Glassy pumice*. Colour smoke-gray. Vesicular. Glistening, pearly. Fracture promiscuous fibrous. Translucent. Between hard and semi-hard. Very brittle. Feels rough, sharp, and meagre. Sp. gr. 0·378 to 1·44. It occurs in beds in the Lipari Islands.

2. *Common pumice*. Colour nearly white. Vesicular. Glimmering, pearly. Fracture

fibrous. Translucent on the edges. Semi-hard. Very brittle. Meagre and rough. Sp. gr. 0·752 to 0·914. It melts into a gray-coloured slag. Its constituents are, silica 77·5, alumina 17·5, natron and potash 3, iron mixed with manganese 1·75.—*Klaproth*. It occurs with the preceding.

3. *Porphyritic pumice.* Colour grayish-white. Massive. Minutely porous. Glimmering and pearly. Sp. gr. 1.661. It contains crystals of felspar, quartz, and mica. It is associated with claystone, obsidian, pearlstone, and pitchstone-porphyry. It occurs in Hungary, at Tokay, &c.

PUS. The fluid of ulcers or abscesses.

PUTREFACTION. The spontaneous decomposition of such animal or vegetable matters as exhale a fetid smell is called putrefaction. The solid and fluid matters are resolved into gaseous compounds and vapours which escape, and into an earthy residuum. See ADIPOCERE and FERMENTATION, of which *genus* putrefaction is merely a *species*. As the grand resolvent of organic matter is water, its abstraction by drying, or fixation by cold, by salt, sugar, spices, &c. will counteract the process of putrefaction. The atmospheric air is also active in putrefaction; hence, its exclusion favours the preservation of food; on which principle, some patents have been obtained.

PUZZOLANA. A kind of volcanic ashes found at Vesuvius, Pompeii, &c. used in water-mortar, or in hydraulic lime. The red or white ashes are reckoned the best. These ashes need to be mixed with lime. See CEMENTS. M. Bruyere finds that an excellent artificial puzzolana may be obtained by heating a mixture of three parts clay, and one part slacked lime, by measure, for some hours to redness. *Annales de Mines*, ix. 550.

PYRALLOLIT. A new mineral belonging to the talc family, found in the lime quarry of Storgard, at the point of Pargas in Finland. It has the singular property of blackening before the blowpipe at a low red heat; and of afterwards becoming white at a higher temperature. It occurs crystallized in quadrangular prisms of which the angles are 94° 36′ and 85° 24′. Surface dull. Lustre greasy. Fracture dull-earthy. Sp. gr. 2·57. In powder phosphorescent with heat, emitting a bright bluish light. Its constituents are, silica 56·62, magnesia 23·38, alumina 13·38, lime 3·38, protox. manganese 0.99, peroxide of iron 0·09, water 3·58, bituminous matter and loss 6·38 in 100. *M. Julin*, *Annals of Phil.* i. 235.

PYRENEITE. Colour grayish-black. Massive, and crystallized in rhomboidal dodecahedrons. Glistening, and metal-like. Fracture uneven. Opaque. Hard. Sp. gr. 2·5? It melts with intumescence, into a yellowish-green vesicular enamel. Its constituents are, silica 43, alumina 16, lime 20, oxide of iron 16, water 4.—*Vauquelin*. It occurs in primitive limestone, in the Pic of Eres-Lids, near Bareges, in the French Pyrenees.

PYRITES. Native compounds of metal with sulphur. See the particular metallic ORES.

PYROGOM. A variety of diopside.

PYROMETER. The most celebrated instrument for measuring high temperatures is that invented by the late Mr. Wedgewood, founded on the principle, that clay progressively contracts in its dimensions, as it is progressively exposed to higher degrees of heat. He formed his white porcelain clay into small cylindrical pieces, in a mould, which, when they were baked in a dull red heat, just fitted into the opening of two brass bars, fixed to a brass plate, so as to form a tapering space between them. This space is graduated: and the farther the pyrometric clay gauge can enter, the greater heat does it indicate. The two converging rules are placed at a distance of 0.5 of an inch at the commencement of the scale, and of 0·3 at the end.

Mr. Wedgewood sought to establish a correspondence between the indications of his pyrometer and those of the mercurial thermometer, by employing a heated rod of silver, whose expansions he measured, as their connecting link. The clay-piece and silver rod were heated in a muffle.

When the muffle appeared of a low red heat, such as was judged to come fully within the province of his thermometer, it was drawn forward toward the door of the oven; and its own door being then nimbly opened by an assistant, Mr. Wedgewood pushed the silver piece as far as it would go. But as the division which it went to could not be distinguished in that ignited state, the muffle was lifted out, by means of an iron rod passed through two rings made for that purpose, with care to keep it steady, and avoid any shake that might endanger the displacing of the silver piece.

When the muffle was grown sufficiently cold to be examined, he noted the degree of expansion which the silver piece stood at, and the degree of heat shown by the thermometer pieces measured in their own gauge; then returned the whole into the oven as before, and repeated the operation with a stronger heat, to obtain another point of correspondence on the two scales.

The first was at 2¼° of his thermometer, which coincided with 66° of the intermediate one; and as each of these last had been before found to contain 20° of Fahrenheit's, the 66 will contain 1320; to which add 50, the degree of his scale to which the (0) of the intermediate thermometer was adjusted, and the sum 1370 will be the degree of Fahrenheit's corresponding to his 2¼°.

The second point of coincidence was at 6¼° of his, and 92° of the intermediate; which 92 being, according to the above proportion, equivalent to 1840 of Fahrenheit, add 50 as before to this number, and his 6½° is found to fall upon the 1890th degree of Fahrenheit.

It appears hence that an interval of four degrees upon Mr. Wedgewood's thermometer is equivalent to an interval of 520° upon that of Fahrenheit; and, consequently, one of the former to 130° of the latter; and that the (0) of Mr. Wedgewood corresponds to 1077½° of Fahrenheit.

From these data it is easy to reduce either scale to the other through their whole range; and from such reduction it will appear, that an interval of near 480° remains between them, which the intermediate thermometer serves as a measure for; that Mr. Wedgewood's includes an extent of about 32000 of Fahrenheit's degrees, or about 54 times as much as that between the freezing and boiling points of mercury, by which mercurial ones are naturally limited; that if the scale of Mr. Wedgewood's thermometer be produced downward in the same manner as Fahrenheit's has been supposed to be produced upward, for an ideal standard, the freezing point of water would fall nearly on 8° below (0) of Mr. Wedgewood's, and the freezing point of mercury a little below 8½°; and that, therefore, of the extent of now measurable heat, there are about 5-10ths of a degree of his scale from the freezing of mercury to the freezing of water; 8° from the freezing of water to full ignition; and 160° above this to the highest degree he has hitherto attained.

Mr. Wedgewood concludes his account with the following table of the effects of heat on different substances, according to Fahrenheit's thermometer, and his own.

	Fahr.	Wedg.
Extremity of the scale of his thermometer	32277°	240°
Greatest heat of his small air furnace	21877	160
Cast-iron melts	17977	130
Greatest heat of a common smith's forge	17327	125
Welding heat of iron, greatest	13427	95
Welding heat of iron, least	12777	90
Fine gold melts .	5237	32
Fine silver melts .	4717	28
Swedish copper melts	4587	27
Brass melts .	3807	21
Heat by which his enamel colours are burnt on	1857	6
Red heat fully visible in day-light	1077	0
Red heat fully visible in the dark	947	— 1
Mercury boils . .	600	$3\frac{676}{1000}$
Water boils .	212	$6\frac{633}{1000}$
Vital heat . .	97°	$7\frac{542}{1000}$°
Water freezes .	32	$8\frac{41}{1000}$
Proof spirit freezes .	0	$8\frac{222}{1000}$
The point at which mercury congeals, consequently the limit of mercurial thermometers, about	40	$8\frac{528}{1000}$

In a scale of HEAT drawn up in this manner, the comparative extents of the different departments of this grand and universal agent are rendered conspicuous at a single glance of the eye. We see at once, for instance, how small a portion of it is concerned in animal and vegetable life, and in the ordinary operations of nature. From freezing to vital heat is barely a five-hundredth part of the scale; a quantity so inconsiderable, relatively to the whole, that in the higher stages of ignition ten times as much might be added or taken away without the least difference being discernible in any of the appearances from which the intensity of fire has hitherto been judged of. Hence, at the same time, we may be convinced of the utility and importance of a physical measure for these higher degrees of heat, and the utter insufficiency of the common means of discriminating and estimating their force. Mr. Wedgewood adds, that he has often found differences, astonishing when considered as a part of this scale, in the heats of his own kilns and ovens, without being perceivable by the workmen at the time, or till the ware was taken out of the kiln.

Since dry air augments in volume 3-8ths for 180 degrees, and, since its progressive rate of expansion is probably uniform by uniform increments of heat, a pyrometer might easily be constructed on this principle. Form a bulb and tube of platinum, of exactly the same form as a thermometer, and connect with the extremity of the stem, at right angles, a glass tube of uniform calibre, filled with mercury, and terminating below in a recurved bulb, like that of the Italian barometer. Graduate the glass tube into a series of spaces equivalent to 3-8ths of the total volume of the capacity of the platina bulb, with 3-4ths of its stem. The other fourth may be supposed to be little influenced by the source of heat. On plunging the bulb and 2-3ds of the stem into a furnace, the depression of the mercury will indicate the degree of heat. As the movement of the column will be very considerable, it will be scarcely worth while to introduce any correction for the change of the initial volume by barometric variation. Or the instrument might be made with the recurved bulb sealed, as in Professor Leslie's differential thermometers. The glass tube may be joined by fusion to the platinum tube. Care must be taken to let no mercury enter the platinum bulb. Should there be a mechanical difficulty in making a bulb of this metal, then a hollow cylinder of ½ inch diameter, with a platinum stem, like that of a tobacco-pipe, screwed into it, will suit equally well.

PYROPHORUS. By this name is denoted an artificial product, which takes fire or becomes ignited on exposure to the air. Hence, in the German language, it has obtained the name of luft-zunder, or air-tinder. It is prepared from alum by calcination, with the addition of various inflammable substances. Homberg was the first that obtained it, which he did accidentally in the year 1680, from a mixture of human excrement and alum, upon which he was operating by fire.

The preparation is managed in the following manner. Three parts of alum are mixed with two parts of honey or one of flour, or sugar; and this mixture is dried over the fire in a glazed bowl, or an iron pan, diligently stirring it all the while with an iron spatula. At first this mixture melts, but by degrees it becomes thicker, swells up, and at last runs into small dry lumps. These are triturated to powder, and once more roasted over the fire, till there is not the least moisture remaining in them, and the operator is well assured that it can liquefy no more: the mass now looks like a blackish powder of charcoal. For the sake of avoiding the previous above-mentioned operation, from four to five parts of burned alum may be mixed directly with two of charcoal powder. This powder is poured into a phial or matrass, with a neck about six inches long. The phial, which however must be filled three-quarters full only, is then put into a crucible, the bottom of which is covered with sand, and so much sand is put round the former that the upper part of its body also is covered with it to the height of an inch: upon this the crucible, with the phial, is put into the furnace, and surrounded with red-hot coals. The fire, being now gradually increased till the phial becomes red hot, is kept up for the space of about a quarter of an hour, or till a black smoke ceases to issue from the mouth of the phial, and instead of this a sulphureous vapour exhales, which commonly takes fire. The fire is kept up till the blue sulphureous flame is no longer to be seen; upon this the calcination must be put an end to, and the phial closed for a short time with a stopper of clay or loam. But as soon as the vessel is become so cool as to be capable of being held in the hand the phial is taken out of the sand, and the powder contained in it transferred as fast as possible from the phial, into a dry and stout glass made warm, which must be secured with a glass stopper.

We have made a very good pyrophorus by simply mixing three parts of alum with one of wheat-flour, calcining them in a common phial till the blue flame disappeared: and have kept it in the same phial, well stopped with a good cork, when cold.

If this powder be exposed to the atmosphere, the sulphuret attracts moisture from the air, and generates sufficient heat to kindle the carbonaceous matter mingled with it.

Dr. Gobel states, that when tartrate of lead is heated in a glass tube, a very perfect and beautiful pyrophorus is produced. When some of the dark brown mass thus formed is shaken out into the air, it immediately inflames, and brilliant globules of lead cover the ignited surface; some of these changing by degrees into litharge, offer a curious appearance. The ignition continues much longer than with other pyrophori, which circumstance, with the facility of preparation, may make this a convenient method of obtaining fire. The inflammation of those substances, Dr. Gobel remarks, has been attributed principally to the presence of potassium; but this new body affords a proof, that other metallic compounds are susceptible of spontaneous inflammation, on the accession of air.

Dr. Hare prepares pyrophorus, by heating for an hour to a bright cherry-red, in an iron tube, a mixture of 3 parts lamp black, 4 calcined alum, and 8 pearl ashes. When well made, and poured out upon a glass plate (especially if breathed upon), it kindles with a series of small explosions, somewhat like those produced by throwing potassium upon water. There is even danger to the face, from the number and rapidity of these explosions. A ramrod, on being thrust down into a tube containing this pyrophorus, was projected with much violence, and several jets of fire.—*Silliman's Journal*, x. 366.

PYROPE. A sub-species of dodecahedral garnet. Colour dark blood-red, appearing yellowish by transmitted light. In grains. Splendent. Fracture conchoidal. Transparent. Refracts double. Scratches quartz more readily than precious garnet. Sp. gr. 3·718. Its constituents are, silica 40, alumina 28·5, magnesia 10, lime 3·5, oxide of iron 16·5, of manganese 0·25, oxide of chrome 2, loss 1·25.—*Klaproth.* It occurs in trap-tuff, at Ely, in Fifeshire; and in claystone in Cumberland. At Zeblitz, Saxony, it is imbedded in serpentine. It is highly valued as a gem in jewellery.

PYROPHYSALITE. See PHYSALITE.

PYROSMALITE. Colour liver-brown, inclining to pistachio-green. In lamellar concretions, and in regular six-sided prisms, or the same truncated. Shining. Fracture uneven. Translucent. Semi-hard. Streak brownish-white. Brittle. Sp. gr. 3.08. It is insoluble in water, but soluble in muriatic acid with a small residuum of silica. It gives out vapours of chlorine before the blowpipe, and becomes a magnetic oxide of iron. Its constituents are, peroxide of iron 21·81, protoxide of manganese 21·14, sub-muriate of iron 14·09, silica 35·85, lime 1·21, water and loss 5·9.—*Hisinger.* It occurs in a bed of magnetic ironstone, along with calcareous spar and hornblende, in Bjelke's mine in Nordmark, near Philipstadt in Wermeland. It is a very singular compound.

PYROTARTARIC ACID. See ACID (PYROTARTARIC).

PYROXENE. Augite.

PYROXILIC SPIRIT. Mr. Taylor describes in the 60th volume of the Philosophical Magazine, p. 315, a liquid which he obtained from the distillation of wood, which he called Pyroligneous Ether. This substance has been since examined by MM. Macaire and Marcet of Geneva, who have called it Pyroxilic spirit.

It is transparent, colourless, of a strong etherous odour slightly resembling that of ants. Its taste is hot and strong, leaving a flavour of essence of mint. Its sp. gravity is 0·823. Boiling point about 150° F. Its slightly acid properties are due to a little acetic acid. It burns away entirely with a perfectly blue flame. Alcohol dissolves it, in all proportions, but water separates it again. It forms merely an emulsion with water. It does not combine with oil of turpentine. It dissolves camphor; but not olive oil. It also dissolves pure potash.

A kind of ether may be formed by the action of nitric acid and chlorine on it; which shows its analogy to alcohol. The pyroacetic spirit of Chenevix, see SPIRIT (PYROACETIC), differs from this liquid in having a lower specific gravity = 0·786; in taste and smell; in burning with a white flame; and in being quite soluble in oil of turpentine.

Pyroxilic spirit consists, in 100 parts, of
Carbon, 44·53 = 6 atoms.
Oxygen, 46·61 = 4
Hydrogen, 9·16 = 7

Pyroacetic spirit of Chenevix consists of
Carbon, 55·30 = 4 atoms.
Oxygen, 36·50 = 2
Hydrogen, 8·20 = 3

Alcohol sp. g. 0·820, consists, in 100, of
Carbon, 48·8 = 3 atoms.
Oxygen, 39·9 = 2
Hydrogen, 11·3 = 5

There is some mistake in printing the atomic numbers. *Bibliotheque Universelle*, and *Journal of Science*, xvii. 171.

Q

QUACK MEDICINES. The following formulæ for the preparation of certain quack medicines have been published by Dr. Paris in his valuable *Pharmacologia.*

Anderson's Pills.—Aloes, jalap, oil of aniseed.

Aromatic Lozenges of Steel.—Sulphate of iron and tincture of cantharides!

Pectoral Balsam of Honey.—Tincture of benzoin.

Barclay's Antibilious Pills.—Extract of colocynth, 2 drachms; extract of jalap, 1 drachm; almond soap, 1 drachm and a half; guaiacum, 3 drachms; tartarized antimony, 8 grains; essential oils of juniper, caraway, and rosemary, of each 4 drops, formed into a mass with syrup of buckthorn, and divided into 64 pills.

Bates's Anodyne Balsam.—1 part of tincture of opium, 2 parts of opodeldoc.

Black Drop.—Take half a pound of opium sliced, three pints of good verjuice, 1 ounce and a half of nutmegs, and half an ounce of saffron; boil them to a proper thickness, then add a quarter of a pound of sugar, and two spoonfuls of yeast; set the whole in a warm place near the fire for six or eight weeks, then place it in the open air until it becomes a syrup; lastly, decant, filter, and bottle it up. One drop is considered equal to three of the tincture of opium of the pharmacopœia.

Brodum's Nervous Cordial consists of the tinctures of gentian, columba, cardamom, and bark, with the compound spirit of lavender and wine of iron.

Chelsea Pensioner, a cure for rheumatism.—Powdered guaiacum, 1 drachm; rhubarb, 2 drachms; cream of tartar, 1 ounce; flowers of sulphur, 2 ounces; 1 nutmeg finely powdered; make into an electuary, with one pound of clarified honey; two large spoonfuls to be taken night and morning.

Ching's Worm Lozenges.—Chiefly calomel and jalap.

Colley's Depilatory.—Quicklime and sulphuret of potass. (We suspect orpiment in this compound).

Daffy's Elixir.—Compound tincture of senna of the Edinburgh Pharmacopœia, sweetened with treacle, and flavoured with aniseed and elecampane root. *Dicey's Daffy* and *Swinton's Daffy* differ little from each other.

Dalby's Carminative.—Magnesia, 40 gr.; oil of peppermint, 1 drop; of nutmeg, 2 drops; of aniseed, 3 drops; tincture of castor, 30 drops; of assafœtida, 15 drops; of opium, 5 drops; spirit of pennyroyal, 15 drops; compound tincture of cardamoms, 30 drops; peppermint-water, 2 ounces.

Essence of Coltsfoot.—This preparation (says Dr. Paris) consists of equal parts of the balsam of Tolu and the compound tincture of benzoin, to which is added double the quantity of rectified spirit of wine; and this, forsooth, is a *pectoral for coughs!* If a patient, with a pulmonary affection, should recover during the use of such a remedy, I should certainly designate it as a lucky escape, rather than a skilful cure.

Whitehead's Essence of Mustard.—Oil of turpentine, camphor, and spirit of rosemary, with a little flour of mustard to colour it.

Freeman's Bathing Spirits.—Opodeldoc, coloured with Daffy's Elixir.

Godbold's Vegetable Balsam.—Honey and vinegar.

Gowland's Lotion.—A solution of corrosive sublimate, in emulsion of bitter almonds.

James's Analeptic Pills.—James's powder, gum ammoniacum, pill of aloes, with myrrh, of each equal parts, made into a mass with tincture of castor.

Norris's Drops.—A coloured solution of tartarized antimony in rectified spirit.

Remedies for the Hooping-cough.—Either opiates, or medicines containing sulphate of zinc.

Roche's Embrocation for the Hooping-cough.—Olive oil, mixed with half its quantity of the oils of cloves and amber.

Ruspini's Tincture for the Teeth.—Florentine iris root, 8 ounces; cloves, 1 ounce; rectified spirit, 2 pints; ambergris, 1 scruple.

Scouring Drops.—Oil of turpentine, perfumed with essential oil of lemon-peel.

Solomon's Balm of Gilead.—An aromatic tincture, of which cardamoms form the leading ingredient, made with brandy. Some practitioners have asserted that cantharides enter its composition.

Steer's Opodeldoc.—Castile soap, 1 ounce; rectified spirit, 8 ounces; camphor, 3 ounces and a half; oil of rosemary, half a drachm; oil of origanum, 1 drachm; solution of ammonia, 6 drachms.

Taylor's Remedy for Deafness.—Garlic, infused in oil of almonds, and coloured by alcanet root.

QUARTATION is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus, when gold alloyed with silver is to be parted, we are obliged to facilitate the action of the aquafortis by reducing the quantity of the former of these metals to one-fourth part of the whole mass; which is done by sufficiently increasing the quantity of the silver, if it be necessary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. See ASSAY.

QUARTZ. Professor Jameson divides this mineral genus into two species; rhomboidal quartz, and indivisible quartz.

1. *Rhomboidal quartz* contains 14 subspecies. 1. Amethyst. 2. Rock crystal. 3. Milk quartz. 4. Common quartz. 5. Prase. 6. Cat's eye. 7. Fibrous quartz. 8. Iron flint. 9. Hornstone. 10. Flinty slate. 11. Flint. 12. Calcedony. 13. Heliotrope. 14. Jasper.

2. *Indivisible quartz* contains nine subspecies. 1. Float-stone. 2. Quartz sinter. 3. Hyalite. 4. Opal. 5. Menilite. 6. Obsidian. 7. Pitchstone. 8. Pearlstone. 9. Pumice-stone. We shall treat here of the quartz sub-species.

1. *Rose* or *milk quartz.* Colour rose-red, and milk-white. Massive. Shining. Fracture conchoidal. Translucent. It is probably silica, coloured with manganese. It is found in Bavaria, where it occurs in beds of quartz in granite, near Zwiesel, &c.

2. *Common quartz.* Colours white, gray, and many others. Massive, disseminated, imitative, in impressed forms, in supposititious and true crystals. The latter are, a six-sided prism, acuminated on both extremities by six planes; a simple six-sided pyramid, and a double six-sided pyramid. Splendent to glistening. Fracture coarse splintery, and sometimes slaty. Translucent. It is one of the most abundant minerals in nature.

3. *Fibrous quartz.* Colours greenish and yellowish white. Massive, and in rolled pieces. In curved fibrous concretions. Glimmering and pearly. Fracture curved slaty. Translucent on the edges. Nearly as hard as quartz. Not very difficultly frangible. Sp. gr. 3·123? It occurs on the banks of the Moldare in Bohemia.

4. *Quartz*, or *siliceous sinter.* Of this there are three kinds; the common, opaline, and pearly.

§ 1. *Common.* Colours grayish-white and reddish-white. Massive and imitative. Dull. Fracture flat conchoidal. Translucent on the edges. Semi-hard. Very brittle. Sp. gr. 1·81. Its constituents are, silica 98, alumina 1·5, iron 0·5.—*Klapr.* It occurs abundantly round the hot springs in Iceland.

§ 2. *Opaline siliceous sinter.* Colour yellowish white. Massive. Fracture conchoidal. Glimmering. Translucent on the edges. Semi-hard. Brittle. Adheres to the tongue. It occurs at the hot springs in Iceland. It resembles opal.

§ 3. *Pearl sinter*, or *florite.* Colour milk-white. In imitative shapes. Lustre between resinous and pearly. In thin concentric lamellar concretions. Fracture fine grained uneven. Translucent. Scratches glass, but not so hard as quartz. Brittle. Sp. gr. 1·917. Its constituents are, silica 94, alumina 2, lime 4.—*Santi.* It has been found in volcanic tuff and pumice, in the Vicentine. See ROCK CRYSTAL.

QUERCITRON. See DYEING.

QUICKSILVER. See MERCURY.

QUININA or **QUINIA.** A vegetable alkali, extracted from pale cinchona, by a process exactly similar to that described under *Cinchonina.* It is obtained in transparent plates. It is as insoluble in water as cinchonina; but its taste is more bitter. It unites with the acids, forming crystallizable salts. The sulphate is of a dull white colour, silky and flexible: it is, like the alkali, soluble in alcohol; it burns away without leaving any residuum. According to MM. Pelletier and Caventou, it is composed of

Quinina,	100
Sulphuric acid,	10·9147

but M. Baup describes a crystallized sulphate as well as a supersulphate. The first consists of

Quinina,	1 prime,	45
Sulphuric acid,	1	5
Water,	4	4·5
		54·5

The second, of

Quinina,	1 prime,	45
Acid,	2	10
Water,	16	18
		73

The *acetate* is remarkable for the manner in which it crystallizes. Its crystals are flat needles of a pearly appearance, which are grouped in silky bundles, or in stars.

Quinina is very soluble in ether; cinchonina is not. Hence this liquid may be employed to separate these two alkalis.

The sulphate of quinina, in doses of from 6 to 12 grains, has been found an effectual remedy against intermittent fevers. It is said that the red or yellow bark yields the most febrifuge quinina. See *Journal of Science*, x. 391, *and* xii. 327.

Quinina agrees with cinchonina, in affording a large quantity of ammonia, when subjected to destructive distillation, and consequently in containing azote as one of its elements. Analyzed by Mr. Brande, it afforded, in 100 parts,

Carbon,	73·80
Azote,	13·00
Hydrogen,	7·65
Oxygen,	5·55
	100·00

Journ. of Science, xvi. 283.

Analysis by Dumas and Pelletier,

Carbon,	74·14
Hydrogen,	6·77
Azote,	8·80
Oxygen,	10·76

Ann. de Chim. xxiv. 176.

M. Baup adopts 45 as the prime equivalent of quinia. He states its sulphates as follows:—

Neutral sulphate.

1 atom	Quinia,	45	76·272
2	Sulph. acid,	5	8·474
8	Water,	9	15·254
			100·000

Supersulphate in rectangular prisms.

1 atom	45	61·644
2	10	13·698
16	18	24·658
		100·000

Ann. de Chimie, xxvii. 323.

R

RADICAL. That which is considered as constituting the distinguishing part of an acid, by its union with the acidifying principle, or oxygen, which is common to all acids. Thus, sulphur is the radical of the sulphuric and sulphurous acids. It is sometimes called the base of the acid, but base is a term of more extensive application.

RADICAL VINEGAR. See ACID (ACETIC).

RAIN. Mr. Luke Howard, who may be considered as one of our most accurate scientific meteorologists, is inclined to think, that rain is in almost every instance the result of the *electrical* action of clouds upon each other. This idea is confirmed by observations made in various ways, upon the electrical state of clouds and rain; and it is very probable that a thunder-storm is only a more sudden and sensible display of those energies, which, according to the order observable in the creation in other respects, ought to be incessantly and silently operating for more general and beneficial purposes.

In the formation of the rain cloud (*nimbus*), two circumstances claim particular attention; the spreading of the superior masses of cloud, in all directions, until they become like the *stratus*, one uniform sheet; and the rapid motion, and visible decrease, of the *cumulus* when brought under the latter. The *cirri* also, which so frequently stretch from the superior sheet upwards, and resemble erected hairs, carry much the appearance of temporary conductors for the electricity, extricated by the sudden union of minute particles of vapour, into the vastly larger ones that form the rain. By one experiment of Cavallo's, with a kite carrying 360 feet of conducting string, in an interval between two showers, and kept up during rain, it seems that the superior clouds possessed a positive electricity before the rain, which on the arrival of a large *cumulus*, gave place to a very strong negative, continuing as long as it was over the kite. We are not, however, warranted from this to conclude the *cumulus* which brings on rain always negative, as the same effect might ensue from a positive *cumulus* uniting with a negative *stratus*. Yet the general negative state of the lower atmosphere during rain, and the positive indications commonly given by the true *stratus*, render this the more probable opinion. It is not, however, absolutely necessary to determine the several states of the clouds which appear during rain, since there is sufficient evidence in favour of the conclusion, that clouds formed in different parts of the atmosphere, operate on each other, when brought near enough, so as to occasion their partial or entire destruction; an effect which can be attributed only to their possessing before-hand, or acquiring at the moment, the opposite electricities.

It may be objected, says Mr. Howard, that this explanation is better suited to the case of a shower than to that of continued rain, for which it does not seem sufficient. If it should appear, nevertheless, that the supply of each kind of cloud is by any means kept up in proportion to the consumption, the objection will be answered. Now, it is a well known fact, that evaporation from the surface of the earth and waters, often returns and continues during rain, and consequently furnishes the lower clouds, while the upper are recruited from the quantity of vapour brought by the superior current, and continually subsiding in the form of dew, as is evident both from the turbidness of the atmosphere in rainy seasons, and the plentiful deposition of dew in the nocturnal intervals of rain. Neither is it pretended that electricity is any further concerned in the production of rain, than as a secondary agent, which modifies the effect of the two grand predisposing causes,—a falling temperature, and the influx of vapour.

Mr. Dalton, who has paid much attention to meteorology, has recently read before the Manchester Society, an elaborate and interesting memoir on rain, from which I shall extract a table, and some observations.

Mean Monthly and Annual Quantities of Rain at Various Places, being the Averages for many Years, by MR. DALTON.

	Manchester, 33 years.	Liverpool, 18 years.	Chatsworth, 16 years.	Lancaster, 20 years.	Kendal, 25 years.	Dumfries, 16 years.	Glasgow, 17 years.	London, 40 years.	Paris, 15 years.	Viviers, 40 years.	General average.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Fr. In.	Fr. In.	Inch.
Jan.	2·310	2·177	2·196	3·461	5·299	3.095	1·595	1·464	1·228	2·477	2·530
Feb.	2·568	1·847	1·652	2·995	5·126	2·837	1·741	1·250	1·232	1·700	2·295
Mar.	2·098	1·523	1·322	1·753	3·151	2·164	1·184	1·172	1·190	1·927	1·748
April	2·010	2·104	2·078	2·180	2·986	2·017	0·979	1·279	1·185	2·686	1·950
May	2·895	2·573	2·118	2·460	3·480	2·568	1·641	1·636	1·767	2·931	2·407
June	2·502	2·816	2·286	2·512	2·722	2·974	1·343	1·738	1·697	2·562	2·315
July	3·697	3·663	3·006	4·140	4·959	3·256	2·303	2·448	1·800	1·882	3·115
Aug.	3·665	3·311	2·435	4·581	5·039	3·199	2·746	1·807	1·900	2·347	3·103
Sept.	3·281	3·654	2·289	3·751	4·874	4·350	1·617	1·842	1·550	4·140	3·135
Oct.	3·922	3·724	3·079	4·151	5·439	4·143	2·297	2.092	1·780	4·741	3·537
Nov.	3·360	3·441	2·634	3·775	4·785	3·174	1·904	2·222	1·720	4·187	3·120
Dec.	3·832	3·288	2·569	3·955	6·084	3·142	1·981	1·736	1·600	2·397	3·058
	36·140	34·118	27·664	39·714	53·944	36·919	21·331	20·686	18·649	33·977	

"*Observations on the Theory of Rain.*

"Every one must have noticed an obvious connexion between heat and the vapour in the atmosphere. Heat promotes evaporation, and contributes to retain the vapour when in the atmosphere, and cold precipitates or condenses the vapour. But these facts do not explain the phenomenon of rain, which is as frequently attended with an increase as with a diminution of the temperature of the atmosphere.

"The late Dr. Hutton, of Edinburgh, was, I conceive, the first person who published a correct notion of the cause of rain. (See Edin. Trans. vol. i. and ii. and Hutton's Dissertations, &c.) Without deciding whether vapour be simply expanded by heat, and diffused through the atmosphere, or chemically combined with it, he maintained from the phenomena that the quantity of vapour capable of entering into the air increases in a greater ratio than the temperature; and hence he fairly infers, that whenever two volumes of air of different temperatures are mixed together, each being previously saturated with vapour, of vapour.

"The cause of rain, therefore, is now, I consider, no longer an object of doubt. If two masses of air, of unequal temperatures, by the ordinary currents of the winds are intermixed, when saturated with vapour, a precipitation ensues. If the masses are under saturation, then less precipitation takes place, or none at all, according to the degree. Also the warmer the air, the greater is the quantity of vapour precipitated in like circumstances. Hence the reason why rains are heavier in summer than winter, and in warm countries than in cold.

"We now inquire into the cause why less rain falls in the first six months of the year than in the last six months. The whole quantity of water in the atmosphere in January is usually about three inches, as appears from the dew point, which is then about 32°. Now the force of vapour at that temperature is 0·2 of an inch of mercury, which is equal to 2.8 or three inches of water. The dew point in July is usually about 58° or 59°, corresponding to 0·5 of an inch of mercury, which is equal to seven inches of water; the difference is four inches of water, which the atmosphere then contains more than in the former month. Hence, supposing the usual intermixture of currents of air in both the intervening periods to be the same, the rain ought to be four inches less in the former period of the year than the average, and four inches more in the latter period, making a difference of eight inches between the two periods, which nearly accords with the preceding observations." Mr. Daniell's Meteorological Essays contain the best body of information on the phenomena of rain, dew, and climate, which is extant.

RANCIDITY. The change which oils undergo by exposure to the air.

The rancidity of oils is probably an effect analogous to the oxidation of metals. It essentially depends on the combination of oxygen with the extractive principle, which is naturally united with the oily principle. This inference is proved by attending to the processes used to counteract or prevent the rancidity of oils.

REAGENT. In the experiments of chemical analysis, the component parts of bodies may either be ascertained in quantity as well as quality, by the perfect operations of the laboratory, or their quality alone may be detected by the operations of certain bodies called reagents. Thus the infusion of galls is a reagent, which detects iron by a dark purple precipitate; the prussiate of potash exhibits a blue with the same metal, &c. See ANALYSIS, and WATERS (MINERAL).

REALGAR. Sulphuret of arsenic, a native ore.

tory vessels, to collect, receive, and contain the products of distillations.

RED CHALK. A kind of clay iron-stone.

REDDLE. Red chalk.

REDUCTION, OR REVIVIFICATION. This word, in its most extensive sense, is applicable to all operations by which any substance is restored to its natural state, or which is considered as such: but custom confines it to operations by which metals are restored to their metallic state, after they have been deprived of this, either by combustion, as the metallic oxides, or by the union of some heterogeneous matters which disguise them, as fulminating gold, luna cornea, cinnabar, and other compounds of the same kind. These reductions are also called revivifications.

REFRIGERATORY. See LABORATORY.

REGULUS. The name regulus was given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who, expecting always to find gold in the metal collected at the bottom of their crucibles after fusion, called this metal, thus collected, regulus, as containing gold, the king of metals. It was afterwards applied to the metal extracted from the ores of the semi-metals, which formerly bore the name that is now given to the semi-metals themselves. Thus we had regulus of antimony, regulus of arsenic, and regulus of cobalt.

RESIN. The name *resin* is used to denote solid inflammable substances, of vegetable origin, soluble in alcohol, usually affording much soot by their combustion. They are likewise soluble in oils, but not at all in water; and are more or less acted upon by the alkalis.

All the resins appear to be nothing else but volatile oils, rendered concrete by their combination with oxygen. The exposure of these to the open air, and the decomposition of acids applied to them, evidently prove this conclusion.

There are some among the known resins which are very pure, and perfectly soluble in alcohol, such as the balsam of Mecca and of capivi, turpentines, tacamahaca, elemi; others are less pure, and contain a small portion of extract, which renders them not totally soluble in alcohol; such are mastic, sandarach, guaiacum, labdanum, and dragon's blood.

What is most generally known by the name of resin simply, or sometimes of yellow resin, is the residuum left after distilling the essential oil from turpentine. If this be urged by a stronger fire, a thick balsam, of a dark-reddish-colour, called balsam of turpentine, comes over; and the residuum, which is rendered blackish, is called black resin, or colephony.

Resin, analysed by MM. Gay Lussac and Thenard, was found to consist of

Carbon, 75·944
Hydrogen, 10·719 } water 15·156
Oxygen, 13·337 } hydrogen in excess 8.9.

By my analysis resin consists, in 100 parts, of

Carbon, 73.6
Hydrogen, 12.9
Oxygen, 13.5 *Phil. Trans.* 1822.

RESPIRATION. A function of animals, which consists in the alternate inhalation of a portion of air into an organ called the lungs, and its subsequent exhalation. The venous blood, which enters the lungs from the pulmonary artery, is charged with carbon, to which it owes its dark purple colour. When the atmospherical oxygen is applied to the interior of the air-vesicles of the lungs, it combines with the carbon of the blood, forms carbonic acid, which to the amount of from 4·5 to 8 per cent. of the bulk of air inspired is immediately exhaled. It does not appear that any oxygen or azote is absorbed by the lungs in respiration, for the volume of carbonic acid generated is exactly equal to that of the oxygen which disappears. Now, we know that carbonic acid contains its own volume of oxygen. It is probable that the quantity of carbonic acid, produced in the lungs, varies in different individuals, and in the same individual under different circumstances. The change of the blood, from the purple venous to the bright red arterial, seems owing to the discharge of the carbon. An ordinary sized man consumes about 46,000 cubic inches of oxygen *per diem*; equivalent to 125 cubic feet of air. He makes about 20 respirations in a minute; or breathes twice, for every seven pulsations. Dr. Prout and Dr. Fyfe found, that after swallowing intoxicating liquors, the quantity of carbonic acid formed in respiration was diminished. The same thing happens under a course of mercury, nitric acid, or vegetable diet.

RETINITE. Retin-asphalt.—*Hatchett.* Colour yellowish and reddish-brown. Massive, in angular pieces and thick crusts. Surface rough. Glistening, resinous. Fracture uneven. Translucent. Soft. Brittle. At first elastic, but becomes rigid by exposure to the air. Sp. gr. 1·135. On a hot iron, it melts, smokes, and burns, with a fragrant odour; soluble in potash, and partially in spirit of wine. Its constituents are, resin 55, asphalt 42, earth 3. It is found at Bovey Tracy in Devonshire, adhering to brown coal.

RETORT. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck, so bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named retorts. The most capacious part of the retort is called its belly. Its upper part is called the arch or roof of the retort, and the bent part is the neck.

REUSSITE. Colour white. As a mealy efflorescence, and crystallized, in flat six-sided prisms and acicular crystals. Shining. Fracture conchoidal. Soft. Its constituents are, sulphate of soda 66·04, sulphate of magnesia 31·35, muriate of magnesia 2·19, and sulphate of lime 0·42.—*Reuss.* It is found as an efflorescence on the surface, in the country round Sedlitz and Seidschutz.

REVERBERATORY. See LABORATORY.

RHABARBARINE. The name of a supposed alkaline base in rhubarb, described by M. Nani of Milan. *Biblioth. Univers.* xxii. 232, and *Journal of Science*, xvi. 172.

RHODIUM. A new metal discovered among the grains of crude platina by Dr. Wollaston. The mode of obtaining it in the state of a triple salt combined with muriatic acid and soda has been given under the article PALLADIUM. This may be dissolved in water and the metal precipitated from it in a black powder by zinc.

This powder exposed to heat continues black; but with borax it acquires a white metallic lustre, though it remains infusible. Sulphur, or arsenic, however, renders it fusible, and may afterward be expelled by continuing the heat. The button however is not malleable. Its specific gravity appears not to exceed 11.

Rhodium unites easily with every metal that has been tried, except mercury. With gold or silver it forms a very malleable alloy, not oxidated by a high degree of heat, but becoming incrusted with a black oxide when slowly cooled. One-sixth of it does not perceptibly alter the colour of gold, but renders it much less fusible. Neither nitric nor nitro-muriatic acid acts on it in either of these alloys; but if it be fused with three parts of bismuth, lead, or copper, the alloy is entirely soluble in a mixture of nitric acid with two parts of muriatic.

The oxide was soluble in every acid Dr. Wollaston tried. The solution in muriatic acid did not crystallize by evaporation. Its residuum formed a rose-coloured solution with alcohol. Muriate of ammonia and of soda, and nitrate of potash, occasioned no precipitate in the muriatic solution, but formed with the oxide triple salts, which were insoluble in alcohol. Its solution in nitric acid likewise did not crystallize; but silver, copper, and other metals precipitated it.

The solution of the triple salt with muriate of soda was not precipitated by muriate, carbonate, or hydrosulphuret of ammonia, by carbonate or ferroprussiate of potash, or by carbonate of soda. The caustic alkalis however throw down a yellow oxide, soluble in excess of alkali; and a solution of platina occasions in it a yellow precipitate.

The title of this product to be considered as a distinct metal was at first questioned; but the experiments of Dr. Wollaston have since been confirmed by Descotils.—*Phil. Trans.*

RHODONITE. A fibrous ore of manganese, containing silica 39, protoxide of manganese 50, &c.

RHŒTIZITE. Colour white. Massive, and in radiated concretions. Glistening and pearly. Fragments splintery. Feebly translucent on the edges. In other characters, the same as cyanite. It occurs in primitive rocks, with quartz, &c. at Pfitzsci in the Tyrol.

RHOMB SPAR. Colour grayish-white. Massive, disseminated, and crystallized in rhomboids, in which the obtuse angle is 106° 15′. Splendent, between vitreous and pearly. Cleavage threefold oblique angular. Fracture imperfect conchoidal. Harder than calcareous spar; sometimes as hard as fluor. Brittle. Sp. gr. 2·8 to 3·2. It effervesces feebly with acids. Its constituents are, carbonate of lime 56·6, carbonate of magnesia 42, with a trace of iron and manganese.—*Murray.* It occurs imbedded in chlorite slate, limestone, &c. It is found on the banks of Loch Lomond; near Newton-Stewart in Galloway; in compact dolomite in the Isle of Man and the North of England. It has been called bitter spar and muricalcite.

RHUBARB (ROOT OF). Mr. Brande gives the following analysis of this medicine:

Water,	8·2
Gum,	31·0
Resin,	10·0
Extract, tan and gallic acid,	26·0
Phosphate of lime,	2·0
Malate of lime,	6·5
Woody fibre,	16·3
	100·0

ROCHELLE SALT. Tartrate of potash and soda. See ACID (TARTARIC).

ROCK BUTTER. Colour yellowish-white. Massive and tuberose. Glimmering. Fracture straight foliated. Translucent on the edges. Feels rather greasy. Easily frangible. It is alum mixed with alumina and oxide of iron. It oozes out of rocks that contain alum. It occurs at the Hurlett alum-work, near Paisley.

ROCK CORK. See ASBESTUS.

ROCK CRYSTAL. Colour white and brown. In rolled pieces, and crystallized. The primitive form is a rhomboid of 94° 15′ and 85° 45′. The secondary forms are, an equiangular six-sided prism, rather acutely acuminated on both extremities by six planes, which are set on the lateral planes; a double six-sided pyramid; an acute simple six-sided pyramid; an acute double three-sided pyramid. Splendent. Fracture perfect conchoidal. Transparent or translucent. Refracts double, feebly. Scratches felspar. Rather easily frangible. Sp. gr. 2·6 to 2·88. When two pieces are rubbed against each other, they become phosphorescent, and exhale an electric odour. Its constituents are, silica 99⅜, and a trace of ferruginous alumina.—*Bucholz.* Some chemists maintain, that it has one or two *per cent.* of moisture. Crystals of great size and beauty are found in Arran in drusy cavities in granite; but the finest are found in the neighbourhood of Cairngorm in Aberdeenshire, where they occur in granite, or in alluvial soil, along with beryl and topaz; and in the secondary greenstone of Burntisland in Fifeshire. The most magnificent groups of crystals come from Dauphiny.

The varieties enclosing crystals of titanium, the *Venus* hair-stones of amateurs, and those containing actinolite, or the *Thetis* hair-stones, are in much repute, and sell at a considerable price.—*Jameson.*

ROCK SALT. Hexahedral rock salt.

1. *Foliated.* Colours white and gray. Massive, disseminated, and crystallized in cubes. Splendent and resinous. Cleavage threefold rectangular. Fracture conchoidal. Fragments cubic. Translucent. As hard as gypsum. Feels rather greasy. Brittle. It has a saline taste. Sp. gr. 2.1 to 2.2.

2. *Fibrous.* Colour white. Massive, and in fibrous concretions. Glistening, resinous. Fragments splintery. Translucent. It decrepitates when heated. The constituents of Cheshire rock salt, in 1000 parts, are, muriate of soda 983¼, sulphate of lime 6½, muriate of magnesia 0·$\frac{5}{16}$, muriate of lime 0·$\frac{1}{16}$, insoluble matter 10.—*Henry.*

The greatest formation of rock salt is in the muriatiferous clay. The salt is occasionally associated with thin layers of anhydrite, stinkstone, limestone, and sandstone. The principal deposit in Great Britain is in Cheshire. The beds alternate with clay and marle, which contains gypsum. It occurs also at Droitwich in Worcestershire. For other localities see Professor Jameson's Mineralogy, iii. 6.

ROCK WOOD. See ASBESTUS.

ROMANZOVITE. A new mineral found in the lime quarry of Kulla, at Kimito, in Finland. Its colours are brown, brownish-yellow, and blackish-brown. Compact, or in crystalline planes, inclined at an angle of 120° to each other. Fracture small conchoidal like common rosin. Lustre shining, between vitreous and resinous. Translucent, in thin fragments. Hard, giving sparks with steel. Brittle. Scratches glass and felspar; but is scratched by quartz. Sp. gr. 3·6. In powder, light yellow. Melts in the interior flame of the blowpipe. Constituents,

Silica	41·24
Lime	24·76
Alumina	24·08
Oxide of iron . . .	7·02
Magnesia and oxide of manganese	0·92
Volatile parts and loss .	1·98
	100·00

M. Julin. Annals of Phil. i. 233.

ROSESTONE. See LIMESTONE.

ROSE QUARTZ. See Quartz.

ROSELITE. This new mineral occurs in small well-defined translucent crystals of a deep rose colour, on amorphous grayish quartz It comes from Schneeberg in Saxony. It has hitherto been placed with the arseniate of cobalt, from the same locality. It contains arsenic acid, united to oxide of cobalt, lime, and magnesia, elements which constitute the picropharmacolite of Stromeyer. See Pharmacolite. *Annals of Phil.* viii. 439.

RUBELITE. Red tourmalin.

RUBY. See Sapphire.

RUBY-SPINEL. See Spinel.

RUST. Red carbonate of iron.

RUTILE. An ore of titanium.

S

SACLACTATES. See Acid (Saclactic).

SAFFLOWER. See Carthamus.

SAGENITE. Acicular rutile.

SAHLITE. Colours greenish-gray, and green of other shades. Massive, in straight lamellar concretions, and crystallized; in a broad rectangular four-sided prism, approaching the tabular form, or truncated on the lateral edges. Splendent on the principal fracture; on the cross fracture, dull. Cleavage fivefold. Fracture uneven. Translucent on the edges. Harder than augite. Rather brittle. Sp. gr. 3·22 to 3·47. It melts with great difficulty. Its constituents are, silica 53, magnesia 19, alumina 3, lime 20, iron and manganese 4.—*Vauquelin.* It occurs in the Island of Unst in Shetland; in granular limestone in the Island of Tiree; and in Glentilt. It is a subspecies of oblique-edged augite.

SAL ALEMBROTH. A compound muriate of mercury and ammonia. See Alembroth.

SAL AMMONIAC (NATIVE); of which there are two kinds, the *volcanic* and *conchoidal.*

1. *Volcanic.* Colour yellowish and grayish-white. In efflorescences, imitative shapes, and crystallized; in an octohedron; rectangular four-sided prism, acuminated with four planes, set on the lateral planes; a cube truncated on the edges; a rhomboidal dodecahedron, and a double eight-sided pyramid, acuminated with four planes. Shining. Cleavage in the direction of the planes of the octohedron. From transparent to opaque. Harder than talc. Ductile and elastic. Sp. gr. 1·5 to 1·6. Taste sharp and urinous. When rubbed with quicklime, it exhales ammonia. Its constituents are, sal ammoniac 99·5, muriate of soda 0·5. —*Klaproth.* It occurs in the vicinity of burning beds of coal, both in Scotland and England. It is met with at Solfaterra, Vesuvius, Ætna, &c.

2. *Conchoidal.* It occurs in angular pieces, and consists of, sal ammoniac 97·5, sulphate of ammonia 2·5.—*Klaproth.* It is said to occur, along with sulphur, in beds of indurated clay or clay-slate, in the country of Bucharia.—*Jameson.* See Acid (Muriatic).

SAL AMMONIAC. Muriate of ammonia.

SAL AMMONIAC (SECRET). Sulphate of ammonia, so called by its discoverer Glauber.

SAL CATHARTICUS AMARUS. Sulphate of magnesia.

SAL DE DUOBUS. Sulphate of potash.

SAL DIURETICUS. Acetate of potash.

SAL GEM. Native muriate of soda.

SAL GLAUBERI. Sulphate of soda.

SAL MARTIS. Green sulphate of iron.

SAL MIRABILE, or SAL MIRABILE GLAUBERI. Sulphate of soda.

SAL MIRABILE PERLATUM, or SAL PERLATUM. Phosphate of soda.

SAL POLYCHREST GLASERI. Sulphate of potash.

SAL PRUNELLA. Nitrate of potash, cast into flat cakes or round balls, after fusion.

SALIFIABLE BASES, are the alkalis, and those earths and metallic oxides which have the power of neutralizing acidity entirely or in part, and producing salts.

SALIVA. The fluid secreted in the mouth, which flows in considerable quantity during a repast, is known by the name of saliva.

Saliva, beside water, which constitutes at least four-fifths of its bulk, contains the following ingredients:—

1. Mucilage,
2. Albumen,
3. Muriate of soda,
4. Phosphate of soda,
5. Phosphate of lime,
6. Phosphate of ammonia.

But it cannot be doubted, that, like all the other animal fluids, it is liable to many changes from disease, &c. Brugnatelli found the saliva of a patient labouring under an obstinate venereal disease impregnated with oxalic acid.

The concretions which sometimes form in the salivary ducts, &c. and the tartar or bony crust which so often attaches itself to the teeth, are composed of phosphate of lime.

SALMIAC. A word sometimes used for sal ammoniac.

SALT. This term has been usually employed to denote a compound, in definite proportions, of acid matter, with an alkali, earth, or metallic oxide. When the proportions of the constituents are so adjusted, that the resulting substance does not affect the colour of infusion of litmus, or red cabbage, it is then called a neutral salt. When the predominance of acid is evinced by the reddening of these infusions, the salt is said to be acidulous, and the prefix, *super*, or *bi*, is used to indicate this excess of acid. If, on the contrary, the acid matter appears to be in defect, or short of the quantity necessary for neutralizing the alkalinity of the base, the salt is then said to be with excess of base, and the prefix *sub* is attached to its name.

The discoveries of Sir H. Davy have however taught us to modify our opinions concerning saline constitution. Many bodies, such as culinary salt, and muriate of lime, to which the appellation of *salt* cannot be refused, have not been proved to contain either acid or alkaline matter; but must, according to the strict logic of chemistry, be regarded as compounds of chlorine with metals.

That great chemist remarks, that very few of the substances which have been always considered as neutral salts, really contain, in their dry state, the acids and alkalis from which they were formed. According to his views, the muriates and fluates must be admitted to contain neither acids nor alkaline bases. Most of the prussiates (or prussides) are shown by M. Gay Lussac to be in the same case. Nitric and sulphuric acids cannot be procured from the nitrates and sulphates, without the intervention of bodies containing hydrogen; and if nitrate of ammonia were to be judged of from the results of its decomposition, it must be regarded as a compound of water and nitrous oxide. To this position it might perhaps be objected, that dry sulphate of iron yields sulphuric acid by ignition in a retort, while oxide of iron remains. Only those acids, says he, which are compounds of oxygen and inflammable bases, appear to enter into combination with the fixed alkalis and alkaline earths without alteration, and it is impossible to define the nature of the arrangement of the elements in their neutral compounds. The phosphate and carbonate of lime have much less of the characters attributed to neutro-saline bodies than chloride of calcium (muriate of lime), and yet this last body is not known to contain either acid or alkaline matter. M. Gay Lussac supposes, that a chloric acid, without water or hydrogen, of one prime proportion of chlorine and five of oxygen, exists in all the hyperoxymuriates (chlorates), but he does not support his proposition by any proof. The hyperoxymuriates were shown by Sir H. Davy, in 1811, to be composed of one prime of chlorine, one of a basis, and six of oxygen. Now hydrogen, in the liquid chloric acid of M. Gay Lussac, may be considered as acting the part of a base; and to be exchanged for potassium in the salt hypothetically called chlorate of potash. It is an important circumstance in the law of definite proportions, that when one metallic or inflammable basis (potassium or hydrogen, for example), combines with certain proportions of a compound as hyperoxygenated chlorine, all the others combine with the same proportions.

M. Gay Lussac states, that if the chloric acid be not admitted as a pure combination of chlorine and oxygen, neither can the hydronitric or hydrosulphuric acids be admitted as pure combinations of oxygen. This is perfectly obvious. An acid composed of five proportions of oxygen, and one of nitrogen, is altogether hypothetical; and it is a simple statement of facts to say, that liquid nitric acid is a compound of one prime equivalent of hydrogen, one of azote, and six of oxygen (such acid has a sp. gr. considerably greater than 1·50). The only difference therefore between nitre and hyperoxymuriate of potash is, that one contains a prime of azote, and the other a prime of chlorine.—Thus,

Nitrate of potash.	*Chlorate of potash.*
1 prime azote,	1 prime chlorine,
6 primes oxygen,	6 primes oxygen,
1 prime potassium.	1 prime potassium.

In each, substitute hydrogen for its kindred combustible, potassium, and you have the liquid acids.

The chloriodic acid, the chlorocarbonous, and the binary acids, containing hydrogen, as muriatic and hydriodic, combine with ammonia without decomposition, but they appear to be decomposed in acting upon the fixed alkalis, or alkaline earths; and yet the solid substances they form have all the characters which were formerly regarded as peculiar to neutral salts, consisting of acids and alkalis, though none of them contain the acid, and only the two first of the series contain the alkalis from which they are formed. The preceding views of saline constitution seem to be perfectly clear and satisfactory; and place in a conspicuous light the paramount logic of the English chemist.

The solubility of salts in water is their most important general habitude. In this menstruum they are usually crystallized; and by its agency they are purified and separated from one another, in the inverse order of their solubility. The most extensive series of experiments on the solubility of salts, which has been published, is that of Hassenfratz, contained in the 27th, 28th, and 31st volumes of the *Annales de Chimie*. Dr. Thomson has copied them into the third volume of his System: and I should also have willingly followed the example, were I not aware, from my own researches, that several of Hassenfratz's results are erroneous. It is ten years since I commenced a very extensive train of experiments on this subject, so important to the practical chemist, but unforeseen obstructions have hitherto prevented their completion. Many of Hassenfratz's determinations, however, are very nearly correct. But his statement of the relation between the density of slacked lime, and the proportion of its combined water, is so absurd, that I wonder that a person of his reputation should have published it, and that Dr. Thomson should have embodied it in his system. In one experiment, 10000 grains of lime, sp. gr. 1.5949, combined with 1620 of water, give a hydrate of sp. gr. 1.4877; and, in another, 10000 grains of lime, sp. gr. 1.3175, combined with 1875 of water, form a hydrate of sp. gr. 0.972. Four parts of lime sp. gr. 1.4558, combined with 1 of water, are stated to yield a hydrate of sp. gr. 1.400; and with 2 of water, of specific gravity 0.8983! Now, the last proportion forms a mass greatly denser than water, instead of being much lighter than proof spirits.

"Mr. Kirwan has pointed out," says Dr. Thomson, "a very ingenious method of estimating the saline contents of a mineral water whose specific gravity is known; so that the error does not exceed one or two parts in the hundred. The method is this:—subtract the specific gravity of pure water from the specific gravity of the mineral water examined (both expressed in whole numbers), and multiply the remainder by 1·4. The product is the saline contents, in a quantity of the water, denoted by the number employed to indicate the specific gravity of distilled water. Thus, let the water be of the specific gravity 1.079, or in whole numbers 1079. Then the specific gravity of distilled water will be 100. And 1079 — 1000 + 1·4 = 110.6 = saline contents in 1000 parts of the water in question; and, consequently, 11.06 (erroneously printed 110.6) in 100 parts of the same water." Divested of its superfluous tautology, this rule is: Multiply by 140 the decimal part of the number, representing the sp. gr. of the saline solution, and the product is the dry salt in 100 grains. "This formula," adds the Doctor, "will often be of considerable use, as it serves as a kind of standard to which we may compare our analysis." *System*, vol. iii. p. 231.

With solutions of nitre and common salt, it gives tolerable approximations; and hence, I fancy, that from these solutions the rule must have been framed. But for solution of sulphate of soda, this *kind of standard* gives a quantity of dry salt nearly *double*, and for that of sal ammoniac, less than *one-half* the real quantity present.

M. Gay Lussac published in the Ann. de Chimie et de Phys. xi. 296, an important memoir on the solubility of salts, from which I shall make a few extracts.

One is astonished, says this excellent chemist, on perusing the different chemical works, at the inaccuracy of our knowledge respecting the solubility of the salts. They satisfy themselves with the common observation, that the salts are more soluble in hot than in cold water, and with the solubility of a few of them at a temperature usually very uncertain; yet it is upon this property of salts that their mutual decomposition, their separation, and the different processes for analyzing them depend. As a chemical process, the solution of the salts deserves peculiar attention; for though the causes to which it is due are the same as those which produce other combinations, yet their effects are not similar. It is to be wished that this interesting part of chemistry, after remaining so long in vague generalities, may at last enter the domain of experiment, and that the solubility of each body may be determined, not merely for a fixed temperature, but for variable temperatures. In the natural sciences, and especially in chemistry, general conclusions ought to be the result of a minute knowledge of particular facts, and should not precede that knowledge. It is only after having acquired this knowledge, that we can be sure of the existence of a common type, and that we can venture to state facts in a general manner.

The determination of the quantity of salt which water can dissolve is not a very difficult process. It consists in saturating the water exactly with the salt whose solubility we wish to know at a determinate temperature, to weigh out a certain quantity of that solution, to evaporate it, and weigh the saline residue. However, the saturation of water may present considerable uncertainty; and before going further it is proper to examine the subject.

We obtain a perfectly saturated saline solution in the two following ways. By heating the water with the salt, and allowing it to cool to the temperature whose solubility is wanted; or by putting into cold water a great excess of salt, and gradually elevating the temperature. In each case, it is requisite to keep the final temperature constant for two hours at least, and to stir the saline solution frequently, to be quite sure of its perfect saturation. By direct experiments made with much care, M. Gay Lussac ascertained that these two processes give the very same result, and that of consequence they may be employed indifferently.

Yet Dr. Thomson says, he found that water retains more oxide of arsenic when saturated by cooling, than when put in contact with the oxide without any elevation of temperature; but the reason I am persuaded was, that he employed too little oxide of arsenic relatively to the water, and that he did not prolong the contact sufficiently. We perceive in fact, on a little reflection, that saturation follows in its progress a decreasing geometrical progression, and that the time necessary for completing it depends upon the surface of contact of the solvent and the body to be dissolved.

It happens often that the solution of a salt which does not crystallize, and which, for that reason, we consider as saturated, yields saline molecules to the crystals of the same nature plunged into it; and it has been concluded from this, that the crystals of a salt impoverish a solution, and make it sink below its true point of saturation. The fact is certain; it is even very general; but I am of opinion that it has been ill explained.

Saturation in a saline solution of an invariable temperature is the point at which the solvent, always in contact with the salt, can neither take up any more, nor let go any more. This point is the only one which should be adopted, because it is determined by chemical forces, and because it remains constant as long as these forces remain constant. According to this definition, every saline solution which can let go salt without any change of temperature, is of necessity supersaturated. It may be shown that, in general, supersaturation is not a fixed point, and that the cause which produces it is the same as that which keeps water liquid below the temperature at which it congeals.

"I shall now give an account of the experiments which I have made on the solubility of the salts.

"Having saturated water with a salt at a determinate temperature, as I have explained above, I take a matrass capable of holding 150 to 200 grammes of water, and whose neck is 15 to 18 centimetres in length. After having weighed it empty, it is filled to about a fourth part with the saline solution, and weighed again. To evaporate the water, the matrass is laid hold of by the neck by a pair of pincers, and it is kept on a red-hot iron at an angle of about 45°, taking care to move it continually, and to give the liquid a rotatory motion, in order to favour the boiling, and to prevent the violent bubbling up which is very common with some saline solutions, as soon as, in consequence of evaporation, they begin to deposit crystals. When the saline mass is dry, and when no more aqueous vapours are driven off at a heat nearly raised to redness, I blow into the matrass, by means of a glass tube fitted to the nozzle of a pair of bellows, in order to drive out the aqueous vapour which fills it. The matrass is then allowed to cool, and weighed. I now know the proportion of water to the salt held in solution, and this is expressed by representing the quantity of water to be 100. Each of the following results is the mean of at least two experiments:—

Solubility of Chloride of Potassium.

Temperature centigrade.	Chloride dissolved by 100 water.
0.00°	29.21
19.35	34.53
52.39	43.59
79.58	50.93
109.60	59.26

Solubility of Chloride of Barium.

Temperature centigrade.	Salt dissolved in 100 water.
15.64°	34.86
49.31	43.84
74.89	50.94
105.48	59.58

In these experiments, the chloride of barium is supposed to be anhydrous; but as when it is crystallized it retains two proportions of water, 22·65, for one of chloride, 131.1, we must of necessity, in order to compare its solubility with that of other salts, increase each number of solubility by the same number multiplied into the ratio of 22.65 to 131·1, and diminish by as much the quantity of water. On making this correction, the preceding results will be changed into the following:—

Temperature.	Salt dissolved in 100 water.
15.64°	43.50
49.31	55.03
74.89	65.51
105.48	77·89

Solubility of Chloride of Sodium.

Temperature.	Salt dissolved in 100 water.
13.89°	35.81
16.90	35.88
59.93	37·14
109.73	40.38

Solubility of Sulphate of Potash.

Temperature.	Salt dissolved in 100 water.
12.72°	10.57
49.08	16.91
63.90	19.29
101.50	26.33

Solubility of Sulphate of Magnesia.

Temperature.	Salt dissolved in 100 water.
14.58°	32.76
39.86	45.05
49.08	49.18
64.35	56.75
97.03	72.30

The sulphate of magnesia is here supposed anhydrous; but as it crystallizes retaining seven portions of water, 79.3, for one proportion of salt, 74.6, each number which expresses the solubility, must be increased by this number multiplied by the ratio of 79.3 to 74.6, and the corresponding quantity of water diminished as much. We shall thus have for the solubility of crystallized sulphate of magnesia the following results:—

Temperature.	
14.58°	103.69
39.86	178.34
49.08	212.61
64.35	295.13
97.03	644.44

These results are no longer proportional to the temperatures; they augment in a much greater ratio.

Solubility of Sulphate of Soda.

Temperature.	Salt soluble in 100 water. Anhydrous.	Salt soluble in 100 water. Crystallised.
0.00°	5.02	12.17
11.67	10.12	26.38
13.30	11.74	31.33
17.91	16.73	48.28
25.05	28.11	99.48
28.76	37.35	161.53
30.75	43.05	215.77
31.84	47.37	270.22
32.73	50.65	322.12
33.88	50.04	312.11
40.15	48.78	291.44
45.04	47.81	276.91
50.40	46.82	262.35
59.79	45.42	—
70.61	44.35	—
84.42	42.96	—
103.17	42.65	—

We see by these results, that the solubility of sulphate of soda follows a very singular law. After having increased rapidly to about the temperature of 33°, where it is at its maximum, it diminishes to 103.17°, and at that point it is nearly the same as at 30.5°. The sulphate of soda presents the second example of a body whose solubility diminishes as the temperature augments; for Mr. Dalton has already observed the same property in lime.

Solubility of Nitrate of Barytes.

Temperature.	Salt dissolved in 100 water.
0.00°	5.00
14.95	8.18
17.62	8.54
37.87	13.67
49.22	17.07
52.11	17.97
73.75	25.01
86.21	29.57
101.65	35.18

Solubility of Nitre.

Temperature.	Salt dissolved in 100 water.
0.00°	13.32
5.01	16.72
11.67	22.23
17.91	29.31
24.94	38.40
35.13	54.82
45.10	74.66
54.72	97.05
65.45	125.42
79.72	169.27
97.66	236.45

Solubility of Chlorate of Potash.

Temperature.	
0.00°	3.33
13.32	5.60
15.37	6.03
24.43	8.44
35.02	12.05
49.08	18.96
74.89	35.40
104.78	60.24

The principal uses of the muriate of soda have already been mentioned under the article *muriatic acid*. In addition, it may be observed, that almost all graminivorous animals are fond of it, and that it appears to be beneficial to them, when mixed with their food. Wood steeped in a solution of it, so as to be thoroughly impregnated with it, is very difficult of combustion: and in Persia it is supposed to prevent timber from the attack of worms, for which purpose it is used in that country. Bruce informs us, that in Abyssinia it is used as money; and it is very probable, that the pillars of fossil glass, in which the Abyssinians are said by Herodotus to have enclosed the bodies of their relations, were nothing but masses of rock salt, which is very common in that part of Africa.

Salt was supposed by the ancients to be so detrimental to vegetation, that, when a field was condemned to sterility, it was customary to sow it with it salt. Modern agriculturists, however, consider it as a useful manure.

We are indebted to Dr. Henry for a very elaborate investigation of the different varieties of common salt. The following table contains the general statement of his experiments.

	Kind of salt.	Insol. matter.	Mur. lime.	Mur. magn.	Total earthy mur.	Sulph. lime.	Sulph. magn.	Total sulphs.	Total muriates.	Pure muriate of soda.
For. bay salt.	St. Ube's,	9	trace	3	3	23½	4½	28	40	960
	St. Martin's,	12	do.	3½	3½	19	6	25	40½	959½
	Oleron,	10	do.	2	2	19¼	4½	23¾	35¾	964¼
Brit. salt fr. sea-water.	Scotch (common),	4	—	28	28	15	17½	32½	64½	935½
	Scotch (Sunday),	1	—	11½	11½	12	4½	16½	29	971
	Lymington (com.),	2	—	11	11	15	35	50	63	937
	Ditto (cat),	1	—	5	5	1	5	6	12	988
Cheshire salt.	Crushed rock,	10	0·1/16	0·3/16	0·¼	6½	—	6½	16¾	983¼
	Fishery,	1	0·¼	0·¾	1	11¼	—	11¼	13¼	986¾
	Common,	1	0·¼	0·¾	1	14½	—	14½	16½	983½
	Stoved,	1	0·¼	0·¾	1	15½	—	15½	17½	982½

" In sea salt prepared by rapid evaporation, the insoluble portion is a mixture of carbonate of lime with carbonate of magnesia, and a fine siliceous sand; and in the salt prepared from Cheshire brine, it is almost entirely carbonate of lime. The insoluble part of the less pure pieces of rock salt is chiefly a marly earth, with some sulphate of lime. The quantity of this impurity, as it is stated in the table, is considerably below the average, which in my experiments has varied from 10 to 45 parts in 1000. Some estimate of its general proportion, when ascertained on a larger scale, may be formed from the fact, that Government, in levying the duties, allow 65 pounds to the bushel of rock salt, instead of 56 pounds, the usual weight of a bushel of salt."—*Henry.* Phil. Trans. for 1810, part 1st. The contamination of the Scotch variety with that septic bitter salt, muriate of magnesia, accords perfectly with my own experiments.

" That kind of salt, then," says this able chemist, " which possesses most eminently the combined properties of hardness, compactness, and perfection of crystals, will be best adapted to the purpose of packing fish and other provisions, because it will remain permanently between the different layers, or will be very gradually dissolved by the fluids that exude from the provisions; thus furnishing a slow but constant supply of saturated brine. On the other hand, for the purpose of preparing the pickle, or of striking the meat, which is done by immersion in a saturated solution of salt, the smaller grained varieties answer equally well; or, on account of their greater solubility, even better," provided they be equally pure. His experiments show, that in compactness of texture the large grained British salt is equal to the foreign bay salt. Their antiseptic qualities are also the same.

SALTS, (TABULAR VIEW OF), expressing their Form, Density, Solubility in Water, Habitudes with the Atmosphere, Composition, and Prime Equivalent.

SALTS OF ALUMINA.—Prime Equivalent 2·25—3·75 *Brande*; 3·375 *Phillips*.

Name.	Form.	Sp. Gr.	Solubil. in Water at		Action of Atmosphere.	Composition.			Prime Equivalent.
			60°.	212°.		Acid.	Base.	Water.	
Acetate	Acicular	1·245	?		Deliquescent	65·0	23·5	11·5	
Arseniate	Massive	?	0		0	7·75	2·25	6·75	16·75 ?
Benzoate	Dendritical	?	?		Deliquescent			?	
Borate	?	0	?					?	
Camphorate	Pulverulent	?	0·05		0			?	
Carbonate	?								
Fluate	Pulverulent	?	0					?	
Soda-fluate, or cryolite									
Gallate	Prisms								
Lactate	Gummy				0			?	
Malate	Pulverulent		0						
Mellate	Flaky powder				Deliquescent				
Muriate	Gelat. or powder		Very soluble		Deliquescent	29·8	30	40·2	
Sub-Nitrate	Soft plates	1·645	Very soluble		Deliquescent	30	20	50	22·5
Oxalate	Yellow mass		Idem			45	22	33	
Phosphate	Pulverulent		0			3·5	2·25	3·375	9·125 ?
Seleniate	Idem		0						
Suberate	Massive								
Succinate	Prisms								
Sulphate	Pearly plates		Very soluble		0	40	40·9 alumina.		
Do.	Pulverulent								
Sulph. of alum. and potash	Octohedrons	*1·69	*0·087	0·75	Efflorescent	20; (6·75 alumina, 6 potash); 28·125 water.			
Sulph. of alum. and soda	Octohedrons	*1·6	*1·1			20; 6·75 alumina, 4 soda, 28·125 water.			
Sulph. of alum. and ammon.			Soluble			Sulph. al. 21·75. Sulph. amm. 7·125; 28·125.			
Sulphite	Pulverulent		0						
Tartrate	Gummy mass		Very soluble		0				
Tartrate						71	19·5	9·5	
Tartrate of pot. and alum.	Idem		Idem		0				
Tungstate	Pulverulent		0						
Urate, or lithate	Pulverulent								

Salts of Ammonia.—Prime Equivalent 2·125.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°.	Solubil. in Water at 212°.	Action of Atmosphere.	Composition. Acid.	Composition. Base.	Composition. Water.	Prime Equivalent.
Acetate	Four-sided prisms	?			Deliquescent	7	2·125	7·875	9·125
Arseniate	Four-sided rect. prisms					78·5	21·5	?	?
Binarseniate	Acicular					78·0	10·7	11·3	?
Arsenite	Gummy								
Benzoate	Plumose				Deliquescent	14·5	2·125	1·125	
Boletate	Flat four-sided prisms		0·38						
Borate	Like borax					37·95	30·32	31·73	
Camphorate	Opaque mass		0·01	0·33	Deliquescent				
Carbonate (sesqui)	Octohedral		0·33		Evaporates	8·25	4·25	2·25	14·75
Do. scentless, or bicarb.	Pulverulent				0	5·5	2·125	2·25	9·875
Chlorate	Acicular		Very soluble		Evaporates				
Chlorocarbonite	Pulverulent		Do.		Deliquescent	6·25	4·25		10·5
Chromate	Dendritical, yellow		Soluble			75·5	24·5		
Citrate	Long prisms		Very soluble			6.125	2·125	1·125	9·375
Ferroprussiate	Yellow hexangular		Do.						
Fluate	Massive		Do.						
Fluoborate	Pulverulent					8·5	2·125		
Formate			Soluble		Volatile				
Hydriodate	Cubical		Very soluble		Deliquescent	15·625	2·125		17·75
Hydroprussiate	Do. prismat. and plum.		Soluble		Evaporates				
Hydrosulphuret	Acicular		Do.		Evaporates				
Hypophosphite			Very soluble						
Hyposulphite	Spicular mass		Do.			6	2·125		
Iodate	Small grains								
Lactate	Gummy mass								
Lithate	White powder								
Malate	Massive								
Meconiate	Acicular stars		0·66			40	42	18	
Mellate	Six-sided								
Molybdate	Semitransparent mass		Soluble		Deliquescent				
Muriate	Four-sided pyramidal	*1·52	0·30		0	4·625	2·125		6·75

Nitrate	Six-sided prisms	1·58	0·5	2·0	Deliquescent	6·75	2·125	[illegible]	[illegible]
Oxalate	Four-sided prisms	1·582	0·045			4·5	2·125	2·25	8·875
Binoxalate	Four-sided prisms					9	2·125	9	
Moroxylate	Long prisms		Soluble						
Phosphate	Octohedral	1·8	0·5		0	44·5	27	28·5	
Biphosphate	Prism with square basis					61·79	14·85	23·36	
Phosphite	Massive		Very soluble						
Purpurate	Quadrangular prisms		0·00066						
Pyrolithate	Silver-white plates		Soluble						
Seleniate	Four-sided prisms								
Suberate	Parallelopipeds		Very soluble		Deliquescent				
Succinate	Acicular		Do.			6·25	2·125	2·25	?
Sulphate	Six-sided prisms		0·5	1·0	Deliquescent	5	2·125	3·375	10·5
Sulphite	Do. and four-sided		1·0		Deliquescent				
Sulphuroprussic	Massive		Very soluble						
Tartrate	Polygonous prisms		Do.			9·25	2·125		
Tungstate	Scales and 4-sid. needles		Soluble		0	15	2·125	2·25	19·375

SALTS OF ANTIMONY.—Prime Equivalent of Oxide 13.—6·5 *Thomson.*

Acetate	Small crystals		Soluble						
Benzoate	Crystals		Do.		0				
Oxalate	Crystallized grains		Slightly soluble						
Succinate									
Tartrate	Gelatinous								
Tart. of potash and ant.	Tetrahedros		0·066	0·5	Efflorescent	44·2 ; 39·76 antimony ; 16 potash.			

SALTS OF BISMUTH.—Prime Equivalent of Oxide 10.

Acetate	Talky crystals		Soluble						
Arseniate	White powder		0						
Benzoate	Acicular		Soluble		0				
Carbonate	White powder		0			7·5	86·2	6·3	
Chromate	Yellow powder		0			6·5	10	2·25	
Muriate	Small prisms								
Nitrate	Four-sided prisms		Decomposed		Deliquescent	34·2	48.8	17	
Oxalate	White powder		0			4·5	10		
Phosphate	Crystals		Soluble		0				
Succinate	Yellow plates								
Sulphate	Acicular		Decomposed			100	197·5		
Tartrate	White powder		0			8·25	10	5·625	

SALTS OF BARYTES.—Prime Equivalent 9·75.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°	212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Acetate	Prismatic needles	1·828	0·88	0·96	0	35	58	7	
Antimoniate	White powder		0						
Antimonite	Silky needles		Slightly soluble		0				
Arseniate	Powder		0		0	42·94	57·06		
Arsenite	Do.		0						
Benzoate	Crystalline		Soluble		0				
Boletate	White plates		Scarcely						
Borate	White powder		0						
Camphorate	Thin plates		Scarcely		0				
Carbonate	Pyramids and columns	4·331	Do.		0	2·75	9·75		12·5
Chlorate	Square prisms		0·25			9·5	9·75		19·25
Chromate	Yellow powder		0			40	60		16·25
Citrate	Silky flakes					50 acid and water, 50 base.			
Ferroprussiate	Yellow rhomboidal prisms		0·0005	0·01		34·3	49·1	16·6	
Fluate	White powder								
Fluosilicate	Hard small crystals								
Formate	Four-sided oblique prisms				0	32	68.0		
Hydriodate	Fine prisms		Very soluble			15·65	9·75		25.4
Hydrosulphuret	Silky scales		Soluble						
Hypophosphite			Very soluble						
Iodate	Powdery		0·03	0·16		20·5	9·75		30·25
Lactate	Gummy mass		Soluble						
Lithate	White powder		0						
Malate	White powder								
Mellate	Flakes								
Muriate	Tables	2·83	0·43 (at 190°)		0	4·5 chlorine		8·75 barium	13.25
Nitrate	Octohedrons	2·9	0·083;	0·25	0	6·75	9·75		16·5
Oxalate	Powder		0		0	31·62	68·38		
Phosphate	Do.	1·286	0		0	100	214·46		13·25 ?
Biphosphate	Square prisms					7	9·75	2·25 ?	
Pyrocitrate	Crystalline powder		0·066	0·02		43·9	56·1		
Sulphate, see HEAVY SPAR	Crystals	4·3	0		0	5	9·75		14·75
Sulphite	White powder	1·694	0		0	100	241·79	4·91	
Sulphuroprussiate	Slender prisms		Soluble		Deliquescent	100	234·9		
Tartrate	Granular crystals		Slightly soluble			9·25	9·75		
Bitartrate	Right prisms		0·124			18·5	9·75	2·25	

SALTS OF CADMIUM.—Prime Equivalent of Oxide

Acetate	Stellular prisms		Soluble	0	7	8	2·25	
Borate	White powder		0		27·88	72·11		
Carbonate	Do.		0		25·45	75·54		
Chromate	Yellow powder		Slightly		6·5	8	5·625	
Citrate	Do.		0					
Muriate	Rectangular prisms		Soluble	Efflorescent	38·6 chlorine		61·4 metal	
Nitrate	Prismatic rays		Soluble	Deliquescent	35·78	42·15	22·06	
Oxalate	White powder		0		4·5	8	3·375	
Phosphate	Do.				30·71	69·29		
Sulphate	Rectangular prisms		Very soluble	Efflorescent	28·52	45·95	25·52	
Tartrate	Small needles		Scarcely		9·25	8	2·25	

SALTS OF CERIUM.—Prime Equivalent of Oxide 6·75.

Acetate	Granular crystals		Very soluble					
Benzoate	White powder							
Carbonate	Silvery grains		0		23	65	12	
Muriate	Four-sided prisms		Soluble	Deliquescent				
Nitrate	Crystals		Soluble					
Deutoxalate	Red powder		0					
Protoxalate	White powder							
Phosphate	Powder		0					
Deutosulphate	Octohed. and acicular		0	Efflorescent				
Tartrate	Powder		0					

SALTS OF COBALT.—Prime Equivalent of Oxide 4·25.

Acetate			Very soluble	Deliquescent				
Binantimoniate	Red crystalline grains		Soluble		52	14	33·3	
Arseniate	Four-sided prisms		0	0	7·75	4·25	4·5	?
Borate	Reddish powder		Scarcely					
Carbonate	Reddish-blue do.		0		2·75	4·25	1·125	
Lactate	Crusts		0·026					
Muriate	Blue crystals		Very soluble	Deliquescent				
Nitrate	Red prisms		Soluble	Deliquescent	6·75	4·25	6·75	
Oxalate	Red powder		0		4·5	4·25	2·25	
Phosphate	Do.				3·5	4·25	2·25 ?	
Sulphate	Rhomboidal prisms		0·06		26	30	44	
Bisulphate	Long four-sid. prisms		Soluble	Efflorescent	10	4·25	3·375	
Tartrate	Red crystals		Do.		9·25	4·25	2·25	

SALTS OF COPPER.—Prime Equivalent of Oxide 10.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°. 212°.	Action of Atmosphere.	Composition. Acid.	Composition. Base.	Composition. Water.	Prime Equivalent.
Binacetate	Four-sided pyramids	1·78	Soluble	0	14	10		24
Calcareous acetate	Eight-sided prisms		Soluble	0	28	10 oxide, 7 lime, 12·4 water.		
Antimoniate	Green powder		0					19
Arseniate	Pyramids and prisms		0					
Benzoate	Small crystals		Slightly	0				
Borate	Gelatinous		0	0				
Carbonate	Various		0	0	2·75	10		
Chlorate	Green mass		Soluble					
Chromate	Brown powder		0		6·5	5	2·25	?
Citrate	Green crystals							
Ferroprussiate	Brown powder		0					
Fluate	Blue crystals		Soluble					
Formate	Six-sided prisms	1·815	0.12	Efflorescent	32·7	35·4	31·9	
Hyposulphite	Colourless mass		Soluble					
Muriate	Tetrahedrons		Soluble		26·42	73·58 orange oxide.		
Deutomuriate	Rectang. parallelopipeds	1·68	Very soluble	Deliquescent	40·2	59·8 black oxide.		
Nitrate	Parallelopipeds	2·174	Do.	Deliquescent	37·05	30·95	32 water.	
Oxalate	Acicular		Soluble	0	4·5	5	1·125	
Ammonia-oxalate	Rhomboidal plates		0	0	47·5	25 oxide, 10·5 ammonia, 17 water.		
Do.	Flat six-sided prisms		Soluble	Efflorescent	36·0	39	16·29	8·71
Do.	Pulverulent			0	43	45·6	9·72	1·7
Potash-oxalate	Six-sided prisms		Soluble	Efflorescent	36·46	20·5	25 pot.	18
Do.	Rhomb. parallelopipeds		Do.		40·5	22·5	27	10
Soda-oxalate	Acicular four-sided prisms		0	0	46·5	23·5 oxide, 19 soda, 11 water.		
Phosphate	Blue-green powder	1·4158	0		35	49·5	15·5 water.	
Subnitrate	Pulverulent		0	0	18·9	66	15·1	
Sulphate	4 sid. pyr. with 4 sid. prisms							
Bisulphate	Oblique parallelopipeds	*2·2323	*0·33	Efflorescent	31·4	32·3	36·3	
Subsulphate	Green powder		0		21·3	64·2	14·5	
Sulphite of protoxide	Red crystals		0		32·2	56·8	11	
Sulph. of copp. and potash	Yellow crystals				73·25 sulph. of copper, 12·68 sulph. potash.			
Sulph. of amm. and copp.	Crystals				20 bisulph. cop. 7·125 sulph. am. 14·625 w.			
Tartrate	Blue-green crystals		Slightly		9·25	5	3·375	?
Potash tartrate	Blue crystals							

SALTS OF GLUCINA.—Prime Equivalent 3·25.

Acetate	Gummy mass		Soluble				
Carbonate	White soft powder		0	0			
Chromate	Yellow mass		Soluble				
Chromo-sulphate	Dendritic crystals		Do.				
Nitrate	Pulverulent		Very soluble	Deliquescent			
Phosphate	White powder		0	0			
Succinate	Powder		0				
Sulphate	Gummy mass, or acicular		Very soluble	Deliquescent	100	64·1	
Bisulphate					100	32·1	
Sesquisulphate					100	98·4	

SALTS OF GOLD.—Prime Equivalent of Oxide 28.

Muriate (super)	4. sid. prisms and octohed. Yellow needles.		Soluble				
Muriate (neutral)	Ruby-red mass		Do.	Deliquescent			
Nitrate	Brown liquid						
Soda-muriate	Crystalline		Soluble	0	69·3 chlor. of gold, 14·1 chlor. of sod., 16·6 w.		

SALTS OF IRIDIUM.

Muriate	Red crystallized mass, or octohed. crystals.		Soluble				

SALTS OF IRON.—Prime Equivalent of protoxide 4·5 ; of peroxide 5.

Acetate	Green prisms	1·368	Soluble				
Acetate of peroxide	Gelatinous mass		Do.	Deliquescent			
Antimoniate	White or yellowish powd.		0				
Arseniate	Powder and cubes	3	0		36	52	12
Arseniate of peroxide	Brown-red powder				42·4	37·2	20·4
Boletate of peroxide	Red powder		0				
Benzoate	Yellow powder		0				
Borate	Pale yellow powder		0				
Carbonate	Pulver. or in rhombs	3·33	0		36 ;	59·5 protoxide ;	2
Subcarbonate	Pulverulent		0		24	76	
Citrate	White powder		Soluble				
Bicitrate	Crystalline powder						
Citrate of peroxide	Brown mass		Very soluble	Deliquescent			

Salts of Iron (continued).

Name.	Form.	Sp. gr.	Solubil. in Water at 60°.	Solubil. in Water at 212°.	Action of Atmosphere.	Composition. Acid.	Composition. Base.	Composition. Water.	Prime Equivalent.
Ferroprussiate of protox.	White powder								
Ferroprussiate of perox.	Blue powder		0						
Fluate	White powder		0						
Gallate of peroxide	Black powder		0						
Hyposulphite	Glutinous mass								
Lactate of protoxide	Four-sided needles		Scarcely		0				
Malate	Brown mass								
Molybdate	Brown powder		0						
Muriate	Flat rhomboidal plates		Soluble						
Muriate of peroxide	Orange mass		Very soluble		Deliquescent				
Nitrate	Liquid								
Nitrate of peroxide	Gelatinous or rectangular four-sided prisms		Very soluble		Deliquescent				
Persesquinitrate	Rhombs and prisms		Soluble		Deliquescent	10·125	5	9	
Subpernitrate						6·75	40	2·25	
Oxalate	Prisms		Soluble			55	45 protoxide		
Oxalate of peroxide	Yellow powder		Scarcely						
Phosphate	Blue powd. and in prisms	2·6	0			21	45 protoxide; 34 water.		
Phosphate of peroxide	White powder		Nearly insolub.						
Superphosphate	Brown-red powder		Do.						
Persesquiphosphate	White powder		Insoluble		0	5·25	5	9	
Pertrisphosphate	Brown powder		Idem		0	3·5	15	3·375 ?	
Succinate	Brown radiated crystals								
Succinate of peroxide	Brown-red powder		0			61·5 acid and water; 38·5 oxide.			
Sulphate	Green rhomboidal prisms	*1·754	*0·45			28·9	25·7	45·4	
Sulphate of peroxide									
a. Neutral	White mass								
b. Sub-bisulphate	Red-yellow powder		0			20	80 peroxide.		
c. Deutosulphate	Octohedrons		Soluble			31·6	15·8	52·6 water.	
d. Tritosulphate	Mass		Do.		Deliquescent	60	40		
Persesquisulphate	Red mass		Soluble		Deliquescent	7·5	5		
Pertetrasulphate	Red powder		Insoluble		0	5	20		
Potash-sulphate	Green crystals		Do.		Efflorescent				

Amm. persulph.	Octohedrons		0·33		Sulph. iron. 25: sulph. amm. 7·125, water 28·125.			
Tartrate	Lamellar crystals							
Tartrate of peroxide	Red jelly							
Potash-tartrate	Crystals							
Tungstate, or Wolfram	Black powder		0					
Salts of Lead.—Prime Equivalent of Oxide 14.								
Acetate	Rhomboidal prisms	2·345	0·27 0·29	0	7	14	3·375	24·375
Subacetate	Crystalline laminæ		Soluble		13·70	61·5	24·8	
Antimoniate	White powder		0					
Arseniate	Powder		0		35·7	64·3		
Benzoate	White crystals		Soluble		49·66	46·49	3·85	
Sub-benzoate					26	74		
Borate	White powder		0					
Carbonate	Do. and crystallized	7·24	0		2·75	14		16·75
Citrate	Ditto.		0		34·18	65·82		
Chlorate	Crystalline plates		Soluble					
Chromate	Yellow powder and four-sided prisms	6	0		31·853	68·147		20·5
Ferroprussiate	White powder		0					
Fluate	Brilliant plates		0					
Formate					4·625	14	1·125	
Gallate	Crystalline powder		0		36·5	63·5		
Hydriodate	Orange-yellow		0					
Hyposulphite	White powder		0		29·7	70·3		
Lactate	Granular		Soluble					
Superlactate	Brown mass		Ditto					
Sublactate	Yellow powder		Ditto		17	83		
Malate	White powd. or silv. crys.		0					
Submalate	White powder		0					
Supermalate	Liquid		Soluble					
Molybdate	Yellow cubes	5·7	0		39·185	60·815		
Muriate	White powder, and small six-sided prisms	1·823	0·0459	0	24·83	75·17		
Submuriate	White or yellow powder							

SALTS OF LEAD (continued).

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°.	212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Nitrate	Tetrahed. and six-sid. pyr.	4		0·13		6·75	14		20·75
Subnitrate	Pearly scales		Soluble			100	412		34·75
Hypo-nitrite	Yellow octohedrons		Ditto			23·925	70·375	5·7	
Subnitrite	Yellow scales		0·0012	0·094		20 acid and water, 80 ox.			
Sub-tetranitrite	Acicular stars		0·007	0·03		10	90		
Oxalate	Crystalline grains		Scarcely			24·5	75·5		
Phosphate	White powder		0			100	314		
Superphosphate	Ditto		0			100	230·6		
Subphosphate	Ditto		0			100	472		
Nitro-phosphate	Small crystals								
Phosphite	White powder		0			19·78	80·22		
Pyrocitrate	Gelatinous mass		Soluble			33·4	66·6		
Pyromalate	Pearly needles		Ditto						
Suberate	Powder		0						
Succinate	Foliated crystals		Scarcely			30·9	69·1		
Subsuccinate						13	87		
Sulphate	White powd. and crys.	1·874	0			5	14		19
Sulphite	White powder		0			22·2	77·8		
Tannate	Powder					65·7	34·3		
Tartrate	White powder		0			37·5	62·5		
Potash-tartrate	Ditto		0						
Bitungstate	Brown powder					37·5	14		?

SALTS OF LIME.—Prime Equivalent 3.5.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°.	212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Acetate	Prismatic needles	1·005	Soluble		0	7	3·5	6·75	17·25
Antimoniate	White powder		Sparingly						
Arseniate	Crystals		0			67	33		
Arsenite	White powder		0						
Benzoate	Pointed crystals		0·05						
Boletate	Flat four-sided prisms		0·009						
Borate	White powder		Scarcely						
Camphorate	White plates		0	0·008	Efflorescent	50	43	7	

Carbonate	Crystallized	2·7	0	0	0	2·75	3·5		
Chlorate	Mass		Very soluble		Deliquescent	9·5	3·5		
Chromate	Yellow silky plates		Soluble						
Citrate	White powder		0			68·83	31·17		
Ferroprussiate	Crystalline grains		Soluble						
Fluate	Cubes	3·15	0			1·25	3·5		4·75
Formate	Crystalline				0				
Gallate			Soluble						
Hydriodate			Very soluble		Deliquescent	15·625	3·5		
Hypophosphite			Do.						
Hyposulphate	Hexahedral plates								
Hyposulphite	Prisms		1·0		0	6	3·5	6·75	
Iodate	Quadrangular prisms		0·0022	0·0098		20·5	3·5 + 3 per cent. water.		
Kinate	White rhomboidal plates		0·2			83 acid and water, 17 base.			
Lactate	Gummy mass		0·05						
Lithate	White powder		0						
Malate	Crystals		Scarcely						
Mellate	Gritty crystals								
Molybdate	Powder								
Moroxylate	Short needles		0·015	0·035	0				
Muriate	Six-sided striated prisms	1·76	4		Deliquescent	48·1	51·9		
Nitrate	Six-sid. prisms, or needles	1·62	4		0	6·75	3·5	3·375	13·625
Oxalate	White powder		0		Hygrometric	56·25	43·75		
Phosphate	Do.		0			100	84·53		
Biphosphate	White mass		Soluble		Deliquescent				
Tetraphosphate	Soft crusts								
Subphosphate	Six-sided prisms	3	0			100·125			
Purpurate			Scarcely						
Pyrocitrate	Acicular mass		0·04			66	34 + 30 per cent. water.		
Pyrolithate	Stalactites					91·4	8·6		
Suberate	Mass		Sparingly						
Succinate	Oblong pointed crystals		Very sparingly		0				
Sulphate	Octohedrons and prisms		0·0022		0	45·8	33·2	21 water.	
Sulphite	Six-sided prisms		0·00125		Efflorescent	54·29	45·71		
Tartrate	White powder		0	0·0016		9·25	3·5	4·5	
Potash-tartrate	Crystals								
Tungstate	Octohedral	6	0		0	80·4	19·4		

SALTS OF LITHIA.—Prime Equivalent 2.3.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°.	Solubil. in Water at 212°.	Action of Atmosphere.	Composition. Acid.	Composition. Base.	Composition. Water.	Prime Equivalent.
Acetate	Subcrystalline mass		Soluble		Deliquescent				
Benzoate	Opaque mass		Do.						
Borate									
Biborate	Crystalline		Less soluble						
Carbonate	White powder		0·01			54·46	45·54		
Chromate	Yellow parallelopipeds		Soluble						
Gallate	Black mass		Do.						
Malate	Syrupy mass								
Muriate	Cube crystals		Soluble		Deliquescent				
Nitrate	Four-sided prisms		Do.		Do.				
Oxalate	Sub-crystalline		Do.						
Binoxalate	Crystalline		Do.						
Phosphate	White powder								
Biphosphate	Crystalline		Soluble						
Saclactate	Small crystals		Do.		Efflorescent				
Sulphate	Four-sided crystals		Do.		0	68·4	31·6		
Bisulphate	Six-sided tables		Do.						
Tartrate	Opaque mass		Do.		Deliquescent				
Bitartrate	Crystalline		Do.						
Potash-tartrate	Rectang. four-sid. prisms		Do.		0				
Soda-tartrate	Do.		Do.		0				
Tungstate	Oblique four-sid. prisms		Do.						

SALTS OF MAGNESIA.—Prime Equivalent 2.5.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°.	Solubil. in Water at 212°.	Action of Atmosphere.	Composition. Acid.	Composition. Base.	Composition. Water.	Prime Equivalent.
Acetate	Viscid mass	1·378	Very soluble		Deliquescent	7	2·5	5·625	
Arseniate	Gummy mass and prisms		0			7·75	2·5	9 ?	
Benzoate	Plumose crystals		Soluble						
Borate	Small crystals and cubes	2·566	0		0	2·75	2·5		
Camphorate	Thin plates		Slightly						
Carbonate	White powder		Very slightly		0	35·7	44·6	19·7	
Carbonate	Crystals		Soluble		Efflorescent	2·75	2·5	3·375	
Carbonate (native)	Massive		0		0	2·75	2·5		

Chlorate	Mass		Very soluble		Deliquescent.	9·5	2·5	14·3 per cent. water.		
Chromate	Yellow six-sided prisms		Very soluble			6·5	2·5	2·25		
Citrate	Opaque soft mass		Do.			66·6	33·34			
Fluate	White powder		0							
Hydriodate	Crystalline mass		Soluble		Deliquescent	15·65	2·5			
Lactate	Granular crystals		Do.							
Malate	Crystals		0·036		0					
Molybdate	Mass		Soluble							
Muriate	Needles	1·6	2		Deliquescent	57	43		*Acid.*	*Base.*
Nitrate	Rhomb. prisms and need.	1·736	1		Do.	43	27	30	(Dry, 6·75	2·5)
Oxalate	White powder		0			48·5	27	24·5		
Binoxalate	Four-sided prisms					9	2·5	7·875		
Phosphate	Six-sided prisms	1·55	0·011		Efflorescent	3·5	2·5	7·875 ?		
Ammon. phosphate	Four-sided prisms and white powder		0			33 phosph.-amm.; 33 phos.-mag.; 33 wat.				
Suberate	Pulverulent		Soluble		Deliquescent					
Succinate	Frothy mass		Do.		Do.					
Sulphate	Quadrangular prisms	1·664	1	1·5	Efflorescent	38	18	44		
Ammonia-sulphate	Octohedrons	1·696	Soluble		0	68 sulph.-mag.; 32 sulph.-amm.; (7 at. w.)				
Potash-sulphate	Rhomboidal crystals		Do.		0	3 sulph.-potash.; 4 sulph.-mag.; (7 at. w.)				
Soda-sulphate	Rhombs truncated		0·33		0	32 sulph.-mag.; 39 sulph.-soda; 28 water.				
Sulphite	Tetrah. and white powd.	1·38	0·05							
Ammonia-sulphite	Crystals		Soluble							
Tartrate	Powder		0			9·25	2·5			
Bitartrate	Acicular crystals		Soluble			18·5	2.5			
Potash-tartrate			Do.		Deliquescent					
Tungstate	Brilliant scales		Do.		0					
Salts of Manganese.—Prime Equivalent of Oxide 4·5.										
Acetate	Rhomboidal tables		0·03		0	70 acid and water; 30 base.				16
Antimoniate	White powder		Slightly		0					
Arseniate	Small crystals		0							
Benzoate	Thin prisms		0·05		0	76 acid; 24 base.				
Carbonate	Yellow-white powder		0		0	2·75	4.5	1·125		
Fluate	White powder		0							
Muriate	Long four-sided tables		Very soluble		Deliquescent					
Nitrate	White needles		Do.		Do.	6·75	4·5	7·875		
Oxalate	White powder		0		0	4·5	4·5	3·375		
Phosphate	Pulverulent		0		0					

SALTS OF MANGANESE (continued).

Name.	Form.	Sp. gr.	Solubil. in Water at 60°.	212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Succinate	Four-sid. prisms, or four-sid. tables and octoh.		0·1			69·7 acid and water; 30·3 base.			
Sulphate	Rhomboidal prisms	2·877	0·31		0	33·66	31	35·34	
Ammonia-sulphate	Rhombs	1·93				1 at. sulph.-mang. + 1 sulph.-amm. + 7 at. w.			
Deuto-sulphate	Red jelly		Soluble		Deliquescent				
Hyposulphate			Do.		Do.				
Tartrate	Brown four-sided prisms					9·25	4·5	1·125	
Tungstate	White powder		0		0				
SALTS of MERCURY.—Prime Equivalent of Protoxide 26,—of Peroxide 27.									
Acetate	Brilliant plates		0·0016		0	6·25	26	4·5	?
Deutacetate	Yellow mass		Very soluble		Deliquescent				
Arseniate	Do.		0		0				
Benzoate	White powder		0		0				
Borate	Yellow powder	2·66	0						
Deuto-carbonate	White powder		0		0	2·75	27		
Chromate	Purple powder		0		0				
Citrate	Mass		Very little						
Deuto-fluate	Lamellar yellow crystals		Soluble						
Hydriodate	Greenish-yellow		0						
Deuto-hydriodate	Orange-red		0						
Lactate	White matter		Soluble						
Deuto-lactate	Red gummy mass		Do.		Deliquescent				
Malate	White powder		0						
Molybdate	White flaky powder		0						
Muriate (calomel)	Four-sided prisms	7·176	0		0	4·5 chlorine; 25 metal.			29·5
Deuto-muriate, or corrosive sublimate	Cubes, or rhomboidal prisms	5·14	0·05	0·5	0	9 chlorine; 25 metal.			34·0
Nitrate	White octohedrons		Soluble			6·75	26		
Per-nitrate	Crystalline prisms		Do.		Deliquescent				
Oxalate	White powder		0						
Deuto-phosphate	White powder	4·98	0			28.5 acid; 71.5 peroxide.			
Saclactate	Do.		0						
Sulphate	White salt		Decomp. by wat.						

Deuto-sulphate	Yellow powder	6·44	0·0005 0·0016	0	15·6 acid; 84·4 peroxide.
Bipersulphate	White crystals		Soluble		10 27 1·125
Tartrate	White or yellow salt		0		9·25 26
Potash-tartrate	Small crystals		Soluble		
Tungstate	Powder		0		

SALTS OF NICKEL.—Prime Equivalent of Oxide 4.25.

Acetate	Green rhomboids		Very soluble		7 4·25 5.625
Arseniate	Apple-green		Soluble		
Carbonate	Pulverulent		0	0	56·4 acid and water; 43·6 base.
Chromate	Pulverulent, red				6.5 4.25 4·5
Muriate	Irregular green crystals		Soluble	Deliquescent	11 acid; 34 oxide; 55 water.
Nitrate	Rhomboidal crystals		Do.	Deliquescent	55 25 20
Ammonia-nitrate	Green crystals		Do.		
Oxalate	Green-white powder		Scarcely soluble		4·5 4·25 4·5
Phosphate	Pulverulent		0		
Sulphate	Four-sided rectang. prisms		Soluble	0	29 25·35 45·65
Ammonia-sulphate	Four-sided flat prisms		Do.		Sulph. nickel 9·25 + 1 at. sulph. amm. + 7 a. w.
Potash-sulphate	Emerald rhomboids		Do.		Sulph. nick. 34·5; sulph. pot. 40·5; 25 water.
Ferreous-sulphate	Green tables		Do.	Efflorescent	
Tartrate	Green powder				9·25 4·25

SALTS OF PALLADIUM.

Muriate	Red solution				
Ammonia-muriate	Liquid		Soluble		
Potash-muriate	Four-sided prisms		Do.		
Soda-muriate	Massive		Do.	Deliquescent	
Nitrate	Dark red liquid				
Prussiate	Yellow flocks		0		

SALTS OF PLATINUM.—Prime equivalent of Oxide 14·15?—*Berzelius.*

Muriate	Irregular crystals		Slightly soluble		
Ammon.-muriate	Yellow powder				Bichlor. plat. 21, mur. ammo. 6·75.
Potash-muriate	Small crystals		Soluble		Chlorine 65; metal 89·8; chloride of potas. 70.
Soda-muriate	Crystals		Do.		Mur. sod. 14·7; mur. plat. 42; water 13·5.
Sulphate	Blackish crust		Do.	Deliquescent	26·3 acid; 73·7 protox.

SALTS OF PLATINUM (continued).

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°.	212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Ammonia-sulphate	Light-brown powder		0		0	Sulph. am. and water 30; oxide 70.			
Barytes-sulphate	Brown powder		0		0				
Potash-sulphate	Blackish grains		0		0	Sulph. pot. 10·84; protox. 78·3; water 10·84.			
Soda-sulphate	Do.		0		0	Sulph. sod. 7·1; protox. 84; water 8·7.			
SALTS OF POTASH.—Prime Equivalent 6.									
Acetate	Plates and prisms		1		Deliquescent	7	6		13
Binacetate	Flat plates							14·6	6·75
Antimoniate	White powder		Scarce sol.	Sol.	0	79·2	20·8		
Antimonite	Do.					76·6	23·4		
Arseniate	Four-sided rectang. prisms	2·64	0·2		0	64	26	10	
Arsenite	Viscid mass		Very soluble		Deliquescent				
Soda-arseniate	Oblique prisms		Soluble			Arsen. pot. 54; ars. sod. 46.			
Sub-arseniate	Mass		Very soluble		Deliquescent				
Benzoate	Plumose crystals		Do.		Do.	14·5	6	3·375	
Bibenzoate	Plates and needles		0·1						
Boletate	Crystalline mass		Very soluble						
Borate	White saline mass, and four-sided prisms		Soluble			100	30	(2·75; 6, *Thomson*).	
Camphorate	Hexagonal crystals		0·01	0·25	0				
Carbonate	White mass	*2.34	*1·0		Deliquescent	2·75	6		8·75
Bicarbonate	Quadrangular prisms	*2.085	0·3	0·83	0	5·5	6	1·125	12·625
Chlorate	Thin plates and rhomboids	1.99	0·062	0·4	0	9·5	6		15·5
Chromate	Yellow four-sided prisms	2·6	0·48		0	6·5	6		12·5
Bichromate	Orange-red four-sided tables and prisms	1·98	0·104		0	13	6		19·0
Citrate	Crystalline mass		Very soluble		Deliquescent	55·5	44·5		
Columbate	Glittering scales		Soluble		0				
Ferroprussiate	Square plate bevelled	1·83	0·3	1·0	0				
Fluate	Crystalline mass		Very soluble		Deliquescent	1·25	6		
Fluo-silicate	Arenaceous powder			0·0066					
Hydriodate	Cubic crystals		Soluble		0	15·025	6		
Hydrosulphuret	Four-sided prisms		Do.		Deliquescent				
Iodate	Crystalline grains		0·077		0	20·5	6		

Lactate	Yellow gummy mass		Soluble						
Lithate	White powder		0						
Malate	Mass		Very soluble		Deliquescent				
Mellate	Long prisms		Soluble						
Molybdate	Rhomboidal plates		Do.						
Muriate	Rectangular prisms	*1·98	0·307		0	36	64	(Chlor. 4·5; potas^{m}. 5).	
Nitrate	Six-sided prisms	*2·073	*0·266,	1·0	0	6·75	6		
Oxalate	Oblique four-sided prisms		0·5			4·5	6	1·125	
Binoxalate	Small rhomboids			0·1	0	9	6	2·25	
Tetra-oxalate	Octohedrons		Soluble			18	6	7·875	
Phosphate	Four-sided prisms		Very soluble		0				
Biphosphate	Gelatinous mass, or striated prisms	2·85	Do.		Deliquescent				
Subphosphate	White powder		0	Soluble	0	35	65		
Hypophosphite	Mass		Very soluble		Deliquescent				
Pyrocitrate	Small needles		0·25		0				
Suberate	Prisms with four unequal sides		Very soluble						
Succinate	Three-sided prisms		Do.		Deliquescent				
Sulphate	Six-sided prisms with six-sided pyramids	*2·67	*0·073	0·2	0	5	6		11
Bisulphate	Six-sided prisms		0·2		0	10	6	2·5	16
Ammonia-sulphate	Brilliant plates		Soluble		0	60 sulph. pot.; 40 sulph. am. (4 at. w.)			
Sulphite	White rhomboidal plates	1·586	1			4	6		10
Hyposulphite	Spicular mass		Very soluble		Deliquescent				
Hyposulphate	Cylindrical prisms		Soluble						
Tartrate	Four-sided rectang. prisms	1·556	1		0	58·7	41·3		
Bitartrate	Small prisms	1·95	0·046	0·07	0	18·5	6		
Ammonia-tartrate	Prisms of 4, 5, or 6 sides		Soluble		Efflorescent				
Tungstate	White powder		Do.		Deliquescent				
Nitro-tungstate	Do.			0·05					
			SALTS OF RHODIUM.						
Muriate	Red liquid								
Soda-muriate	Red rhomboidal crystals		0·63		0				
Nitrate	Red liquid								
Sulphate	Mass		Soluble		Deliquescent				

SALTS OF SILVER.—Prime Equivalent of Oxide 14.75.

Name.	Form.	Sp. Gr.	Solubil. in water at 60°. 212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Acetate	Small needles		Soluble		7	14·75		
Arseniate	Brown powder		0					
Arsenite	Yell. do. passing to brown		0					
Benzoate	Mass		Very soluble	0				
Borate	White powder		0					
Carbonate	Do.		0		2·75	14·75		
Chlorate	Opaque small rhomboids		0·5					
Chromate	Red powder		0		6·5	14·75		
Citrate	Powder		0					
Fluate	Mass		Very soluble					
Lactate	Greenish yellow mass		Do.					
Molybdate	White flakes		0					
Muriate	White curdy mass		0	0	Chlorine 4·5 ; metal 13·875			
Nitrate	6, 4, and 3-sided plates	3·521	1	0	6·75	14·75		
Oxalate	White powder		Scarcely		4·5	14·75		
Phosphate	Yellow powder		0		17	83		
Succinate	Oblong radiated prisms		Soluble					
Sulphate	Brilliant white prisms		0·0115		5	14·75		
Sulphite	Brilliant white grains		Very little					
Hyposulphite	Gray flakes		Soluble					
Ammon.-hyposulphite	White mass, or hexang. pl.		Very soluble		2 primes hypos.-ammon.—1 hyp.-silver.			
Lime-hyposulphite	White mass		Do.					
Potash-hyposulphite	Pearly scales		Little					
Soda-hyposulphite	Thin silky plates		Very soluble					
Tartrate	Saline mass		Soluble		9·25	14·75		
Potash-tartrate	Mass		Do.					

SALTS OF SODA.—Prime Equivalent 4.

Name.	Form.	Sp. Gr.	Solubil. in water at 60°. 212°.	Action of Atmosphere.	Composition. Acid.	Base.	Water.	Prime Equivalent.
Acetate	Striated prisms	2·1	0·35	0	37	23	40	7 acid 4 base, dry.
Arseniate	Rhomboidal prism	1·76	0·025		29·3	15·9	54·8	
Potash-arseniate	Obl. pris. with rhomb. base		Soluble		Arseniate-potash 54 ; arseniate-soda 46.			
Ammonia-arseniate	Do.		Do.					
Binarseniate	Prisms		Do.		63·16	17·13	10·71	

Benzoate	Crystals		Soluble		Efflorescent				
Borate		1·351	0·4 at 149°						
Bi-borate	Hexangular prisms	*1·693	0·05	0·166	Efflorescent	2·75	8	9·0	
Camphorate	Irregular crystals		0·01	0·125	Do.				
Carbonate	Rhomboids	*1·417	1·0		Do.	2·75	4	11·25	$\frac{64}{100}$ water.
Do. ignited	Massive	*2·44				2·75	4		6·75
Sesquicarbonate	Striated masses		Soluble		0	40	39·7	20·3	
Bicarbonate	Four-sided prisms		0·09		0	5·5	4	1·125	
Chlorate	Square plates		Very soluble			9·5	4		13·5
Chromate	Thin six-sided tables		Soluble			6·5	4	13·5	
Citrate	Six-sided prisms		0·66		Efflorescent	60·7	39·3		
Ferroprussiate	Yellow four-sided prisms	1·46	0·22		Do.				
Hydriodate	Flat rhomboids		Very soluble		Deliquescent	15·625	4 + water.		
Iodate	Tufts of prisms and cubes		0·073			20·5	4		
Lithate	White powder								
Malate	Mass		Very soluble		Deliquescent				
Bimalate	Crystals		Soluble		0				
Mellate	Cubes and 3-sided tables		Do.						
Molybdate	Transparent crystals		Soluble		0				
Muriate	Cubes	*1·986	*0·342—0·259		0	4·5 chlorine, 3 sodium,			7·5
Nitrate	Rhomboids	2·00	0·33	1 at 126°	Deliquescent	6·75	4		10·75
Oxalate	Crystalline grains		Little			54·77	45·23		
Binoxalate	Rectangular prisms	1·98	0·025		0	9	4	3·375	
Phosphate	Rhomboidal prisms	*1·519	0·25	6·5	Efflorescent	53·48 20·38	46·52 dry, and 17·67	62 w. crystal.	
Ammon-phosphate	Prismatic columns	1·50	Soluble		Do.	34·49 or phos. sod. 32	14·87 phos. amm. 26·4. (16 at. w.)	9 amm.	41·64 w.
Biphosphate	Prisms		Very soluble			51·50	22·56	25·54	
Hypophosphite			Do.						
Suberate	Mass		Do.		Deliquescent				
Succinate	Four or six-sided prisms		Soluble		0	6·25	4	6·75	
Sulphate	Six-sided prisms channeled	*1·44	*0·394	0·8	Efflorescent	24·76	19·24	56	20·25
Bisulphate	Rhomboids		0·5		Do.				
Ammon-sulphate	Crystals		Soluble		0	Sulph. sod. 9		sulph. am. 7·125	6 at. w.
Sulphite	Four-sided prisms	2·95	0·35	1·0	Efflorescent	24·5	24·5	51 ?	
Hyposulphite	Radiated silky tufts		Soluble		Do.				
Tartrate	Fine needles	1·744	1·0			9·25	4	1·125	
Potash-tartrate	Eight or ten-sided prisms		As the last		Efflorescent	54 tart. pot.		46 tart. sod.	
Tungstate	Elongat. six-sided plates		0·25	0·5		18·75	4	6·75	

Salts of Strontites.—Prime Equivalent 6·5.

Name.	Form.	Sp. Gr.	Solubil. in Water at 60°. 212°.	Action of Atmosphere.	Composition. Acid.	Composition. Base.	Water.	Prime Equival
Acetate	Flat rhomboidal prisms		0·04	Efflorescent	49·5	50·5 ?	14·625	
Arseniate	White powder		0					
Arsenite	Mass		Soluble					
Sub-borate	White powder		0·077					
Carbonate	White powder and semi-transp. striated masses	3·66	0·0065		29·7	70·3		
Chlorate	Needles		Very soluble	Deliquescent	46	26	28	(9·5 6·5 dry
Chromate	Yellow powder		0		6·5	6·5		
Citrate	Small crystals		Soluble					
Ferroprussiate	Mass		0·25	0				
Fluate	White powder		0					
Hydriodate	Mass		Very soluble					
Iodate	Small octohedrons		0·24		(20·5	6·5)	+ water.	
Lactate	Gummy mass		0·12					
Muriate	Tables, and two 8-sided pyramids base to base	2·83	0·43 at 190°	0	4·5 chlor. 5.5 strontium			
Nitrate	Triang. dodecahedron			0	6·75	6.5		
Hydrous	Rhomboids			Efflorescent	6.75	6·5	4·5	
Oxalate	White powder		0·0052	0	40	60 ?	(2 at. w.)	13
Phosphate	Do.		0	0	36·56	63·44		
Hypophosphite	Mass		Very soluble					
Succinate	Arenaceous crystals		Soluble					
Sulphate	White powder and rhomboidal prisms		0·00026 Sol. in hot sul. ac.		43·5	56·5 ?		11
Hyposulphite	Rhomboidal crystals		0·166 at 50°	0				
Hyposulphate	Small six-sided plates		Soluble					
Tartrate	Rhomboidal prisms		0·006		47	53	(3 at. w.)	

Salts of Tellurium.

Muriate	Liquid				
Nitrate	Dendritic crystals		Soluble		
Sulphate	Crimson liquid				

SALTS OF TIN.—Prime Equivalent of Oxide 7·35.

Acetate	Small crystals		Soluble					
Arseniate	White powder		0					
Benzoate	Powder			Sol.				
Borate	White powder							
Nitrate	Yellow liquid							
Ammon.-nitrate			Soluble					
Oxalate	Prismatic crystals		Do.					
Phosphate	Powder		0					
Succinate	Thin broad crystals		Soluble					
Sulphate	Fine prismatic needles							
Deutosulphate	Gelatinous							
Tartrate			Soluble					
Potash-tartrate			Very soluble					

SALTS OF TITANIUM.

Carbonate	Red-white powder					25	75 white oxide	
Muriate	Cubic cryst. or yell. jelly		Soluble					
Nitrate	Elongated rhomboids		Do.					
Phosphate	White precipitate							
Sulphate	Gelatinous mass		Do.					

SALTS OF URANIUM.

Acetate	Yellow four-sided prisms		Soluble					
Ammon.-carbonate	Yellow prisms		Do.			Carb. uran. 30·75, carb. amm. 14·625 4 at. wat.		
Arseniate	Yellow-white powder		0					
Muriate	Yellow-green 4-sided tabl.		Soluble		Deliquescent			
Nitrate	Yellow hexang. tables and 4-sided rectang. prisms		2·15	alcohol 3·33		25	61	14
Subnitrate	Yellow powder		0					
Phosphate	Yellow-white flakes		Scarcely					
Sulphate	Small yell. prisms & tables		1·6	2·2		18	70	12

			212°.	Atmosphere.	Acid.	Base.	Water.
Acetate	Red six-sided plates		Soluble	0			
Arseniate	White powder		0				
Carbonate	Do.		0		18	55	27
Chromate	Dendr. prisms and cubes		Very soluble				
Muriate like the Nitrate	Gummy mass		Do.	Deliquescent			
Oxalate	White powder		0		57·5	42·5	
Phosphate	Gelatinous flakes		0				
Succinate	Cubic crystals		Sparingly				
Sulphate	Red brilliant grains, and rhomboidal prisms	2·79	0·033	0			
Tartrate			Soluble				

SALTS OF ZINC.—Prime Equivalent of Oxide 5·25.

Acetate	Glistening rhomboidal or hexagonal plates		Very soluble	0	7	5·25	7·875
Antimoniate	White crystalline powder		Slightly	0			
Arseniate	White powder		0				
Benzoate	Needles		Soluble				
Borate	White powder		0		In the hydrate		
Carbonate	Do. and crystals		0		2·75 2·75	5·25 5·25	1·125; and in th
Chromate	Orange-red powder		Slightly		6·5	5·25	
Citrate	Small brilliant crystals		0		59	41	
Chlorate	Low octohedrons		Soluble				
Fluate	Gelatinous flocks		0				
Hydriodate	Mass, or prisms		Very soluble	Deliquescent	15·625	5·25	
Iodate	Spherical grains		Slightly				
Lactate	Four-sided prisms		0·02				
Malate	Fine crystals		Soluble				

Muriate	Mass	1·577	Very soluble	Deliquescent	
Nitrate	Striated four-sided prisms	2·0	Do.	Do.	6·75 5·25 6·75
Molybdate	White powder		0		a. b. w.
Oxalate	Do.		Slight		75 per cent. of metal, or 4·5 + 5·25 + 2·25
Phosphate	Tough white magma		0		100 113·8
Biphosphate	Mass		Soluble		
Succinate	Slender foliated crystals		Do.		
Sulphate	4-sided rectang. prisms	1·98	1·4	0	30·96 32·58 36.45 (3 or 6 at. w).
Sulphite	Crystals		Soluble	Into sulphate	
Hyposulphite	Slender four-sided prisms		Do.	Whiten	
Ammon.-Sulph.	Rhomboids		Soluble		1 at. sulph. zinc+1at. sulph. am.+7 at. water
Cobalt-sulphate	Four-sided prisms		Very soluble	Efflorescent	
Iron sulphate	Green rhomboids		Soluble		
Tartrate	Solid		Slight		9·25 5·25
Potash tartrate	Mass		Very soluble		
Tungstate	White powder		0		
			Salts of Zirconia.		
Acetate	Mass		Very soluble	0	
Benzoate			Soluble		
Borate	White powder		0		
Carbonate	Do.		0		44·5 acid and water; 55·5 zircon
Citrate	Do.		0		
Fluate	Do.		0		
Gallate	Do.		0		
Malate			Soluble		
Muriate	Needles		Very soluble	Efflorescent	
Nitrate	Yellow viscid mass		Slight		
Oxalate	White powder		0		
Phosphate	Do.		0		
Sulphate	White powder, or small needles		0	0	
Bisulphate	Stelliform crystals		Soluble		
Sulphite	White powder		0		
Tartrate	Do.		0		

SALT (AMMONIACAL, FIXED). Muriate of lime.

SALT (AMMONIACAL, SECRET) OF GLAUBER. Sulphate of ammonia.

SALT (ARSENICAL, NEUTRAL) OF MACQUER. Superarseniate of potash.

SALT (BITTER, CATHARTIC). Sulphate of magnesia.

SALT (COMMON). Muriate of soda. See ACID (MURIATIC); also end of the article SALT, and ROCK SALT.

SALT (DIGESTIVE) OF SYLVIUS. Acetate of potash.

SALT (DIURETIC). Acetate of potash.

SALT (EPSOM). Sulphate of magnesia.

SALT (FEBRIFUGE) OF SYLVIUS. Muriate of potash.

SALT (FUSIBLE). Phosphate of ammonia.

SALT (FUSIBLE) OF URINE. Triple phosphate of soda and ammonia.

SALT (GLAUBER'S). Sulphate of soda.

SALT (GREEN). In the mines of Wielizka the workmen give this name to the upper stratum of native salt, which is rendered impure by a mixture of clay.

SALT (MARINE). Muriate of soda.

SALT (MARINE ARGILLACEOUS). Muriate of alumina.

SALT (MICROCOSMIC). Triple phosphate of soda and ammonia.

SALT (NITROUS AMMONIACAL). Nitrate of ammonia.

SALT OF AMBER. Succinic acid.

SALT OF BENZOIN. Benzoic acid.

SALT OF CANAL. Sulphate of magnesia.

SALT OF COLCOTHAR. Sulphate of iron.

SALT OF EGRA. Sulphate of magnesia.

SALT OF LEMONS (ESSENTIAL). Superoxalate of potash.

SALT OF SATURN. Acetate of lead.

SALT OF SEDLITZ. Sulphate of magnesia.

SALT OF SEIGNETTE. Triple tartrate of potash and soda.

SALT OF SODA. Subcarbonate of soda.

SALT OF SORREL. Superoxalate of potash.

SALT OF TARTAR. Subcarbonate of potash.

SALT OF VITRIOL. Purified sulphate of zinc.

SALT OF WISDOM. A compound muriate of mercury and ammonia. See ALEMBROTH.

SALT (PERLATE). Phosphate of soda.

SALT (POLYCHREST) OF GLASER. Sulphate of potash.

SALT (SEDATIVE). Boracic acid.

SALT (SPIRIT OF). Muriatic acid was formerly called by this name, which it still retains in commerce.

SALT (SULPHUREOUS) OF STAHL. Sulphite of potash.

SALT (WONDERFUL). Sulphate of soda.

SALT (WONDERFUL PERLATE). Phosphate of soda.

SALTPETRE. Nitrate of potash.

SAND. Sand is an assemblage of small stones.

SAND-BATH. See BATH.

SANDARIC GUM. A resin in yellowish-white tears, possessing a considerable degree of transparency.

SANDIVER, OR GLASS-GALL. This is a saline matter, which rises as a scum in the pots or crucibles in which glass is made.

SANGUIFICATION. That process of living animals by which chyle is converted into blood. I had entertained hopes of being able to present some definite facts on this mysterious subject, but have been disappointed. The latest essay on sanguification is that of Dr. Prout, in the Annals of Philosophy for April, 1819.

SAPPARE. CYANITE.

SAPPHIRE. A sub-species of rhomboidal corundum. It is the *Telesie* of Haüy, and the *perfect corundum* of Bournon. The oriental ruby and topaz are sapphires.

Colours blue and red; it occurs also gray, white, green, and yellow. It occurs in blunt-edged pieces, in roundish pebbles, and crystallized. The primitive figure is a slightly acute rhomboid, or double three-sided pyramid, in which the alternate angles are 86° 4′ and 93° 56′. The following are the usual forms:—a very acute, equiangular, six-sided pyramid; the same truncated on the summit; a perfect six-sided prism; an acute, double, six-sided pyramid; the same acuminated, or truncated in various ways. Splendent, inclined to adamantine. Cleavage parallel with the terminal planes of the prism. Fracture conchoidal. From transparent to translucent. Refracts double. After diamond, it is the hardest substance in nature. The blue variety, or sapphire, is harder than the ruby. Brittle. Sp. gr. 4 to 4.2. Its constituents are,

	Blue.		Red.
Alumina,	98.5		90.0
Lime,	6.5		7.0
Oxide of iron,	1.		1.2
		Loss	1.8
	100.0		100.0
	Klaproth.		*Chenevix.*

Infusible before the blowpipe. It becomes electrical by rubbing, and retains its electricity for several hours; but does not become electrical by heating. It occurs in alluvial soil, in the vicinity of rocks belonging to the secondary or floetz-trap formation, and imbedded in gneiss. It is found at Podsedlitz and Treblitz in Bohemia, and Hohenstein in Saxony; Expailly in France; and particularly beautiful in the Capelan mountains, 12 days' journey from Sirian, a city of Pegu. Next to diamond, it is the most valuable of the gems. The white and pale blue varieties, by exposure to heat, become snow-white, and when cut exhibit so high a degree of lustre, that they are used in place of diamond. The most highly prized varieties are the crimson and carmine-red; these are the oriental *ruby* of the jeweller; the next is *sapphire;* and last, the yellow, or oriental *topaz*. The *asterias*, or star-stone, is a very beautiful variety, in which the colour is generally of a reddish-violet, and the form a rhomboid, with truncated apices, which exhibit an opalescent lustre. A sapphire of 10 carats weight is considered to be worth fifty guineas.—*Jameson.*

SAPHIRIN. Haüyne.

SARCOLITE. A variety of analcime.

SARDE, or **SARDOIN,** a variety of carnelian, which displays on its surface an agreeable and rich reddish-brown colour, but appears of a deep blood-red when held between the eye and the light.

SARDONYX. Another variety, composed of layers of white and red carnelian.

SASSOLINE. Native boracic acid. It is found on the edges of hot springs near Sasso, in the territory of Florence. It consists of boracic acid 86, ferruginous sulphate of manganese 11, sulphate of lime 3.—*Klaproth.*

SATIN SPAR. Fibrous limestone; which see.

SATURATION. Some substances unite in all proportions. Such, for example, are acids in general, and some other salts with water; and many of the metals with each other. But there are likewise many substances which cannot be dissolved in a fluid, at a settled temperature, in any quantity beyond a certain proportion. Thus water will dissolve only about one-third of its weight of common salt, and, if more be added, it will remain solid. A fluid, which holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance does not deprive the fluid of its power of acting on and dissolving some other bodies, and in many cases it increases this power. For example, water saturated with salt will dissolve sugar; and water saturated with carbonic acid will dissolve iron, though without this addition its action on this metal is scarcely perceptible.

The word saturation is likewise used in another sense by chemists. The union of two principles produces a body, the properties of which differ from those of its component parts, but resemble those of the predominating principle. When the principles are in such proportion that neither predominates, they are said to be saturated with each other; but if otherwise, the most predominant principle is said to be subsaturated or undersaturated, and the other supersaturated or oversaturated.

SAUSSURITE. Colours white, gray, and green, massive, disseminated, and in rolled pieces. Dull. Fracture splintery. Faintly translucent on the edges. Difficultly frangible. Hard, scratching quartz. Meagre to the feel. Sp. gr. 3.2. It melts on the edges and angles. Its constituents are, silica 49, alumina 24, lime 10.5, magnesia 3.75, natron 5.5, iron 6.5.—*Klaproth.* It occurs at the foot of Mount Rosa. Professor Jameson places it near Andalusite.

SCALES OF FISH consist of alternate layers of membrane and phosphate of lime.

SCALES OF SERPENTS are composed of a horny membrane, without the calcareous phosphate.

SCAMMONY consists of

	Aleppo.	Smyrna.
Resin,	60	29
Gum,	3	8
Extractive,	2	5
Vegetable debris and earth	35	58
	100	100

Vogel, and Bouillon Lagrange.

SCAPOLITE, OR PYRAMIDAL FELSPAR. Professor Jameson divides it into four sub-species; radiated, foliated, compact red, and elaolite.

1. *Radiated.* Colour gray. Massive, in distinct concretions and crystallized. Primitive figure a pyramid of 136° 38′ and 62° 56′. The secondary forms are, a rectangular four-sided prism, acuminated or truncated. Lateral planes deeply longitudinally streaked. Resinous, pearly. Cleavage double. Fracture fine grained uneven. Translucent. As hard as apatite. Easily frangible. Sp. gr. 2.5 to 2.8. Green scapolite becomes white before the blowpipe, and melts into a white glass. Its constituents are, silica 45, alumina 33, lime 17.6, natron 1.5, potash 0.5, iron and manganese 1.—*Laugier.* It occurs in the neighbourhood of Arendal in Norway, associated with magnetic ironstone, felspar, &c.

2. *Foliated scapolite.* Colours gray, green, and black. Massive, disseminated, and crystallized in low eight-sided prisms, flatly acuminated with four planes. Splendent, vitreous. Fracture small grained uneven. Translucent. Streak white. Brittle. Hardness and sp. gr. as preceding species. It is found in granular granite or *whitestone*, in the Saxon Erzegebirge.

3. *Compact scapolite.* Colour red. Crystallized in long, acicular, four-sided prisms, which are often curved. Glistening. Opaque. Hard in a low degree. Easily frangible. It occurs with the others in metalliferous beds at Arendal.

SCHEELIUM. Tungsten.

SCHIEFER SPAR. See **Slate Spar**.

SCHILLER SPAR. This species contains two sub-species; bronzite and common schiller spar. See **Bronzite**.

Common schiller spar. Colour olive-green. Disseminated, and in granular distinct concretions. Splendent and metallic-pearly. Cleavage single. Opaque. Softer than bronzite. Streak greenish-gray. Easily frangible. Sp. gr. 2.882? It occurs imbedded in serpentine in Fetlar and Unst in Shetland, and at Portsoy in Banffshire; also in Skye, Fifeshire, Calton-hill, near Dumbarton, between Ballantrae and Girvan in Ayrshire, and in Cornwall.

Labradore schiller spar. See **Hypersthene**.

SCHMELZSTEIN. Dipyre.

SCHORL (COMMON). A sub-species of rhomboidal tourmaline. Colour velvet-black. Massive, disseminated, and crystallized, in three, six, and nine-sided prisms. Crystals acicular. Lateral planes longitudinally streaked. Between shining and glistening. Fracture conchoidal, or uneven. Opaque. Streak gray. As hard as quartz. Easily frangible. Sp. gr. 3 to 3.3. It melts into a blackish slag. Its constituents are, silica 36.75, alumina 34.5, magnesia 0.25, oxide of iron 21, potash 6, and a trace of manganese.—*Klaproth*. It exhibits the same electric properties as tourmaline. It occurs imbedded in granite, gneiss, &c. in Perthshire, Banffshire, Cornwall, &c.

SCHORL (BLUE). A variety of Haüyne.

SCHORL (RED AND TITANITIC). Rutile.

SCHORLITE, or SCHORLOUS TOPAZ. *Pycnite* of Werner. Colour straw-yellow. Massive, composed of parallel prismatic concretions, and crystallized in long six-sided prisms. Glistening, resinous. Fracture, small conchoidal. Translucent on the edges. Nearly as hard as common topaz. Brittle. Sp. gr. 3.53. Infusible. Becomes electric by heating. Its constituents are, alumina 51, silica 38.43, fluoric acid 8.84.—*Berzelius*. It occurs at Altenberg in Saxony, in a rock of quartz and mica in porphyry.

SCILLITIN. A white transparent, acrid substance, extracted from squills, by Vogel.

SELENIUM. A new elementary body, extracted by M. Berzelius from the pyrites of Fahlun, which, from its chemical properties, he places between sulphur and tellurium, though it has more properties in common with the former than with the latter substance. It was obtained in exceedingly small quantity from a large portion of pyrites. For the mode of extraction I must refer to his long and elaborate papers, translated from the Annales de

1820.

Professor Stromeyer has lately discovered selenium under two different forms, one of which is altogether new. On diluting some fuming sulphuric acid, such as is made at Nordhausen from the sulphate of iron, he observed that a solid matter separated, which on examination proved to be selenium. One pound of the acid gave on dilution about one grain of selenium. The second source of selenium is in the volcanic productions of the Lipari islands, among which Professor Stromeyer has lately discovered a native sulphuret of selenium. Selenium has also been detected in the Anglesea pyrites. The sulphuric acid made from it having been used in making muriatic acid, the selenium is seen to distil over into the receivers, in the course of two or three days falling down as a reddish brown substance. A portion of this selenium, tested by Mr. Children, gave when heated on platinum foil by a spirit lamp, an azure-blue tinge to the flame. The smell of horse-radish was perceptible, when the substance was heated in a glass tube. In thin laminæ it was transparent, and of a beautiful cinnabar red colour.—*Annals of Phil.* N. S. ix. 52.

When selenium, after being fused, becomes solid, its surface assumes a metallic brilliancy of a very deep brown colour, resembling polished hæmatites. Its fracture is conchoidal, vitreous, of the colour of lead, and perfectly metallic. The powder of selenium has a deep red colour, but it sticks together readily when pounded, and then assumes a gray colour and a smooth surface, as happens to antimony and bismuth. In very thin coats, selenium is transparent, with a ruby-red colour. When heated it softens; and at 212° it is semi-liquid, and melts completely at a temperature a few degrees higher. During its cooling it retains for a long time a soft and semi-fluid state. Like Spanish wax, it may be kneaded between the fingers, and drawn out into long threads, which have a great deal of elasticity, and in which we easily perceive the transparency, when they are flat and thin. These threads, viewed by transmitted light, are red; but, by reflected light, they are gray, and have the metallic lustre.

When selenium is heated in a retort, it begins to boil at a temperature below that of a red heat. It assumes the form of a dark yellow vapour, which, however, is not so intense as that of the vapour of sulphur; but it is more intense than chlorine gas. The vapour condenses in the neck of the retort, and forms black drops, which unite into larger drops, as in the distillation of mercury.

If we heat selenium in the air, or in vessels so large that the vapour may be condensed by the cold air, a red smoke is formed, which has the same circumstances. The characteristic smell of horse-radish is not perceived, till the heat becomes great enough to occasion oxidation.

Selenium is not a good conductor of heat. We can easily hold it between the fingers, and melt it at the distance of one or two lines from the fingers, without perceiving that it becomes hot. It is also a non-conductor of electricity. On the other hand, M. Berzelius was not able to render it electric by friction. It is not hard; the knife scratches it easily. It is brittle like glass, and is easily reduced to powder. Its sp. gr. is between 4.3 and 4.32.

The affinity of selenium for oxygen is not very great. If we heat it in the air, without touching it with a burning body, it is usually volatilized, without alteration; but if it is touched by flame, its edges assume a fine sky-blue colour, and it is volatilized with a strong smell of horse-radish. The odorous substance is a gaseous oxide of selenium, which, however, has not been obtained in an insulated state, but only mixed with atmospherical air. If we heat selenium in a close phial filled with common air, till the greatest part of it is evaporated, the air of the phial acquires the odour of oxide of selenium in a very high degree. If we wash the air with pure water, the liquid acquires the odour of the gas; but as there are always formed traces of selenic acid, this water acquires the property of reddening litmus paper feebly, and of becoming muddy when mixed with sulphuretted hydrogen gas. Selenic oxide gas is but very little soluble in water, and does not communicate any taste to it.

If we heat selenium in a large flask filled with oxygen gas, it evaporates without combustion, and the gas assumes the odour of selenic oxide, just as would have happened if the sublimation had taken place in common air; but if we heat the selenium in a glass ball of an inch diameter, in which it has not room to volatilize and disperse; and if we allow a current of oxygen gas to pass through this ball, the selenium takes fire, just when it begins to boil, and burns with a feeble flame, white towards the base, but green or greenish-blue at the summit, or towards the upper edge. The oxygen gas is absorbed, and selenic acid is sublimed into the cold parts of the apparatus. The selenium is completely consumed without any residue. The excess of oxygen gas usually assumes the odour of selenic oxide. Selenic acid is in the form of very long four-sided needles. It seems to be most readily formed by the action of nitromuriatic acid on selenium. The selenic acid does not melt with heat; but it diminishes a little in bulk at the hottest place, and then

It has a pure acid taste, which le
burning sensation on the tongu
soluble in cold water, and diss
every proportion in boiling wa
zelius infers the composition o
from several experiments, to be,

Selenium, 71·261 100·00
Oxygen, 28·739 40·33

If into a solution of selenic ac
acid, we introduce a piece of zinc
iron, the metal immediately
colour of copper, and the seleni
ally precipitated in the form of r
or blackish flocks, according as
ture is more or less elevated. W
of potash is heated with muriate
selenium is obtained by the deo
perty of the ammonia; but in
always lose a small quantity
which comes over with the wate
of an acid. If we pour dilute
on the compound of selenium a
dissolved in water, seleniuretted
is evolved. Water impregnated
cipitates all the metallic solution
of iron and zinc, when they are n
phur, phosphorus, the earths, an
combine with selenium, forming
Selenic acid neutralizes the bases.
has been recently found in two m
is from Skrickerum, in the parish
in Smoland.

M. Henry Rose of Berlin has
lished an interesting memoir on
seleniurets, found in the Oriental
seminated in magnesian limest
veins of iron that traverse argillac
He converted all the metals
chlorides, by passing chlorine ov
verized ore for half a day, and se
chloride of selenium by means
tility.

1. *Seleniuret of lead.* This wa
frequent. It consists of two atoms
to one of lead; consisting of 27·
+ 72·3 lead.

2. *Seleniuret of lead and cobalt.*
tuents are,

Lead, . . .	6
Cobalt, . . .	
Selenium, . .	3
Iron, . . .	
Loss, . . .	
	10

3. *Selcniuret of lead and copper.*
mineral there were two varieties co
follows :

Selenium,	29·96	34·26
Iron with traces of lead,	0·44	2·08
Lead,	59·67	47·43
Iron,	0·33	
Copper,	7·86	15·45
Undecomposed portion of the mineral,	1·00	silver 1·29
Loss,	0·74	
	100·00	100·51

4. *Seleniuret of lead and mercury*, contains

Selenium, . .	24·97
Lead, . .	55·84
Mercury, . .	16·94
Loss, . . .	2·25
	100·00

—*Ann. de Chim.*, xxix. 113.

SCORZA. A variety of epidote.

SEA FROTH. *Meerschaum.*

SEA SALT. Muriate of soda. See ACID (MURIATIC), and SALT.

SEA SALT (REGENERATED). Muriate of potash.

SEA WAX. Maltha, a white, solid, tallowy-looking fusible substance, soluble in alcohol, found on the Baikal Lake in Siberia.

SEBACIC ACID. See ACID (SEBACIC).

SEBAT. A neutral compound of sebacic acid with a base.

SEDATIVE SALT. Boracic acid.

SEL DE SEIGNETTE. The triple tartrate of potash and soda, or Rochelle salt. See ACID (TARTARIC).

SELENITE. Sparry gypsum.

SEMIOPAL. See OPAL.

SEPTARIA, or *ludi helmontii*, are spheroidal concretions, that vary from a few inches to a foot in diameter. When broken in a longitudinal direction, we observe the interior of the mass intersected by a number of fissures, by which it is divided into more or less regular prisms, of from 3 to 6 or more sides, the fissures being sometimes empty, but oftener filled up with another substance, which is generally calcareous spar. The body of the concretion is a ferruginous marle. From these septaria are manufactured that excellent material for building under water, known by the name of Parker's or Roman cement.—*Jameson.*

SEROSITY. See BLOOD.

SERPENTINE; common, and precious.

1. *Common*. Colour green, of various shades. Massive. Dull. Fracture small and fine splintery. Translucent on the edges. Soft, and scratched by calcareous spar. Sectile. Difficultly frangible. Feels somewhat greasy. Sp. gr. 2·4 to 2·6. Some varieties are magnetic. Its constituents are, silica 32, magnesia 37·24, alumina 0·5, lime 10·6, iron 0·66, volatile matter and carbonic acid 14·16.—*Hisinger*. John and Rose give 10·5 of water in it. It occurs in various mountains. It is found in Unst and Fetlar in Shetland; at Portsoy; between Ballantrae and Girvan; in Cornwall; and in the county of Donegal.

2. *Precious serpentine*. Of this there are two kinds, the splintery and conchoidal.

a. Splintery. Colour dark leek-green. Massive. Feebly glimmering. Fracture coarse splintery. Feebly translucent. Soft. Sp. gr. 2·7. It occurs in Corsica, and is cut into snuff-boxes, &c.

b. Conchoidal. Colour leek-green. Massive and disseminated. Glistening, resinous. Fracture flat conchoidal. Translucent. Semihard. Sp. gr. 2·6. Its constituents are, silica 42·5, magnesia 38·63, lime 0·25, alumina 1, oxide of iron 1·5, oxide of manganese 0·62, oxide of chrome 0·25, water 15·2.—*John*. It occurs with foliated granular limestone in beds subordinate to gneiss, mica-slate, &c. It is found at Portsoy, in Banffshire; in the Shetland Islands, and in the Island of Holyhead. It receives a finer polish than common serpentine.

SERUM. See BLOOD and MILK.

SHALE. Slate-clay and bituminous slate-clay.

SHELLS. Marine shells may be divided, as Mr. Hatchett observes, into two kinds: those that have a porcellanous aspect, with an enamelled surface, and when broken are often in a slight degree of a fibrous texture; and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl.

The porcellanous shells appear to consist of carbonate of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ.

The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure, which is lamellar, the gluten forming their membranes, regularly alternating with strata of carbonate of lime. In these two the gluten is much more abundant.

Mr. Hatchett made a few experiments on land shells also, which did not exhibit any differences. But the shells of the crustaceous animals he found to contain more or less phosphate of lime, though not equal in quantity to the carbonate, and hence approaching to the nature of bone. Linnæus therefore, he observes, was right in considering the covering of the echini as crustaceous, for it contains phosphate of lime. In the covering of some of the species of asterias, too, a little phosphate of lime occurs; but in that of others there is none. *Phil. Trans.*

SHISTUS (ARGILLACEOUS). Clay-slate.

SIBERITE. Red tourmaline.

SIDERO-CALCITE. Brown spar.

SIDERUM. Bergmann's name for phosphuret of iron.

SIENITE OR SYENITE. A compound granular aggregated rock, composed of felspar and hornblende, and sometimes quartz and black mica. The hornblende is the characteristic ingredient, and distinguishes it perfectly from granite, with which it is often confounded; but the felspar, which is almost always red, and seldom inclines to green, forms the most abundant and essential ingredient of the rock. Some varieties contain a very considerable portion of quartz and mica, but little hornblende. This is particularly the case with the Egyptian varieties, and hence these are often confounded with real granite.

As it has many points of agreement with greenstone, it is necessary to compare them together. In greenstone, the hornblende is usually the predominating ingredient; in sienite, on the contrary, it is the felspar that predominates. In greenstone, the felspar is almost always green, or greenish; here, on the contrary, it is as constantly red, or reddish. Quartz and mica are very rare in greenstone, and in inconsiderable quantity; whereas they are rather frequent in sienite. *Lastly*, greenstone commonly contains iron pyrites, which never occurs in sienite.

It has either a simple granular base, or it is granular porphyritic; and then it is denominated porphyritic sienite. When the parts of the granular base are so minute as to be distinguished with difficulty, and it contains imbedded in it large crystals of felspar, the rock is termed sienite-porphyry. It is sometimes unstratified, sometimes very distinctly stratified. It sometimes shows a tendency to the columnar structure. It contains no foreign beds. It occurs in unconformable and overlying stratification, over granite, gneiss, mica-slate, and clay-slate, and is pretty continuous, and covers most of the primitive rocks. It is equally metalliferous with porphyry. In the island of Cyprus, it affords much copper; many of the important silver and gold mines in Hungary are situated in it. The sienite of the forest of Thuringia affords iron. In this country, there is a fine example of sienite in Galloway, where it forms a considerable portion of the hill called Criffle. On the continent, it occurs in the electorate of Saxony; and in Upper Egypt, at the city of Syena, in Thebaid, at the cataracts of the Nile, whence it derives its name. The Romans brought it from that place to Rome, for architectural and statuary purposes.—*Jameson.*

SILICA. One of the primitive earths, which in consequence of Sir H. Davy's researches on the metallic bases of the alkalis and earths, has been recently regarded as a compound of a peculiar combustible principle with oxygen. If we ignite powdered quartz with three parts of pure potash in a silver crucible, dissolve the fused compound in water, add to the solution a quantity of acid, equivalent to saturate the alkali, and evaporate to dryness, we shall obtain a fine gritty powder, which being well washed with hot water, and ignited, will leave pure silica. By passing the vapour of potassium over silica in an ignited tube, Sir H. Davy obtained a dark-coloured powder, which apparently contained silicon, or silicium, the basis of the earth. Like boron and carbon, it is capable of sustaining a high temperature without suffering any change. Aqueous potash seems to form with it an olive-coloured solution. But as this basis is decomposed by water, it was not possible to wash away the potash by this liquid. Berzelius and Stromeyer tried to form an alloy of silicon or silicium with iron, by exposing to the strongest heat of a blast furnace, a mixture of three parts of iron, 1·5 silica, and 0·66 charcoal. It was in the state of fused globules. These freed from the charcoal were white and ductile, and their solution in muriatic acid evolved more hydrogen than an equal weight of iron. The sp. gravity of the alloy was from 6·7 to 7·3, while that of the iron used was 7·8285. From Mr. Mushet's experiments, however, as well as from the constitution of plumbago, we know that carbon will combine with iron in very considerable proportions, and that in certain quantities it can give it a whitish colour and inferior density. Nothing absolutely definitive therefore can be inferred from these experiments. See IRON.

M. Berzelius has lately obtained pure silicium by the combustion of potassium in silicated fluoric gas; as also by the action of potassium on the double fluate of silica and potash, or of silica and soda. The latter salt having the advantage of containing a greater quantity of fluate of silica, under the same weight and bulk, deserves the preference. The salt is easily prepared by saturating aqueous silicated fluoric acid with carbonate of soda, when the very sparingly double salt precipitates, which is to be washed and dried, at a temperature considerably above 212° F. This dry matter in fine powder is to be stratified, with thin slices of potassium, in a glass tube sealed at the end, which is to be uniformly heated at once with a spirit flame. Even before ignition, the silicium is reduced with a slight hissing sound, and some appearance of heat. No gas is disengaged when the salt has been well dried. The mass is allowed to cool. It is hard, agglutinated, porous, of a deep brown colour, which does not alter in the air, merely exhaling the smell of hydrogen, as manganese does, when pressed between the fingers, or breathed upon. It is to be washed with water in successive quantities to remove the fluate of potash that is formed. Some gas is disengaged, but this soon ceases, and though the water be raised to ebullition, the brown powder does not decompose it. The solution obtained by ebullition being very acid, the substance is to be boiled with new portions of water till the liquid manifests no signs of acidity, when it is to be passed through a filter. The powder, being dried, is of a chestnut brown (maroon) colour, containing visibly heterogeneous points of a brighter hue.

The first of the above washings should be with a large quantity of water, so that the liquid which becomes alkaline by the oxidizement of the potassium may be so dilute as to have no tendency to oxidize the silicium and to dissolve it. For this reason, the mass must not be treated with hot water till all the alkalinity be removed. It is thereafter to be treated with boiling water, till a drop of this leaves no stain on evaporation. This process requires much time and a large body of water.

Silicium, obtained by this process, contains some hydrogen, but in less quantity, and probably in the same way as the charcoal of wood, which Sir H. Davy regards as hydrogenated carbon. It contains, besides, some silica, which proceeds from a small portion of the potassium getting oxidized at first, and in this state separating a little silica from the double salt. The hydrogenated silicium is to be heated for some time almost to redness in an open crucible, then it is finally to be ignited. Should the silicium offer to take fire, the crucible is to be instantly covered, and the heat lowered, which will immediately stop the inflammation. After this calcination, the silicium is incombustible in the air, and may be washed from its adhering silica by pure liquid fluoric acid, taking care that no iron or manganese is present; for the alloy thence resulting would dissolve entirely with disengagement of hydrogen. After being treated with this acid, the silicium is to be washed and dried.

Obtained in this way, silicium has a deep nut-brown colour, but not the least metallic lustre. When rubbed with a steel burnisher it presents no trace of brilliancy, opposing a resistance to friction, like an earthy substance. It is incombustible in the atmospheric air, and in oxygen gas. It suffers no change in the flame of the blowpipe, apparently belonging to the most infusible class of bodies. These properties appear at variance with what takes place with the silicium immediately after its reduction by potassium, for it readily burns. M. Berzelius ascribes this difference to the presence of hydrogen in the latter substance, which may be regarded as a *siliciuret of potassium* at first, and after simple washing a *hydruret of silicium*. Ignition, well regulated, expels the hydrogen, without setting the compound on fire; but if hastily induced, the hydrogen kindles the silicium, which then becomes covered with a coat of silica. The condensation which the silicium undergoes by ignition, is the cause of its becoming insoluble in fluoric acid.

Silicium stains and sticks strongly, even when dry, to the glass vessels in which it is kept.

Silicium does not conduct electricity. After its ignition, it is not affected by chlorate of potash, even at a red heat; nor by nitre, till the temperature have become high enough to decompose the nitric acid, and to allow the affinity of its alkaline base to act. At a white heat, nitre attacks it violently.

With carbonate of potash, silicium burns very readily with a lively flame. Gaseous oxide of carbon is disengaged, and the mass blackens from intermixture with charcoal. By taking a small proportion of carbonate of potash, or of soda, as one half the bulk of the silicium, the inflammation takes place much below ignition. With larger proportions of the carbonate, the mass swells up from the development of the gaseous oxide of carbon, takes fire, and burns with a blue flame. With a still greater proportion there is no sign of combustion; the mass does not blacken, but merely exhales the above gaseous oxide.

If the incombustible silicium be heated to moderate redness on platinum foil with nitre, no effect ensues; but if a bit of dry carbonate of soda be made to touch the silicium, a detonation will take place at the expense of the carbonate, and the mass will retain for some time its black colour.

Silicium explodes with lively incandescence with the hydrated fixed alkalis at their melting temperature, much below a red heat. Hydrogen is disengaged, which burns visibly when the bulk of the materials is not too small. The same phenomenon takes place with hydrate of barytes. With acid fluate of potash, silicium explodes at the melting point of the salt, which is far under ignition. It is not altered by borax in a state of fusion.

Silicium, heated to distinct redness in the vapour of sulphur, takes fire and burns, but much less vividly than in oxygen; but the combination will not take place with the incombustible silicium. In moist air, sulphuret of silicium diffuses a strong smell of sulphuretted hydrogen, and speedily loses all its sulphur; but in dry air it may be preserved for a long time. At a red heat, it is roasted, affording sulphurous acid and silica.

Siliciuret of potassium combines readily at a red heat with sulphur, constituting a true double sulphuret of a deep brown or black colour.

Simple sulphuret of silicium, when thrown into water, dissolves immediately, with disengagement of sulphuretted hydrogen. The silicium changes into silica, which dissolves in the water, and if this be in small quantity, such a concentrated solution may be obtained as to gelatinize after a slight evaporation, and to leave silica, after drying, in a transparent cracked mass. It is remarkable to see silica dissolve in such a large proportion in water, at the instant of its formation, and to lose this property by evaporation to such a degree as to become insoluble in acids. This solubility may explain the origin of the crystallizations of silica in drusy cavities, which in many cases could not contain a volume of liquid appreciably larger than that of the crystals themselves.

M. Berzelius did not succeed in combining silicium with phosphorus.

When silicium is heated in a current of chlorine, it takes fire, and continues to burn. If the gas contain some atmospheric air, silica remains in a slender skeleton form. Silicium burns equally well in chlorine, whether or not it had previously been deprived of its combustibility in air. The product condenses into a liquid, which is yellowish with excess of chlorine, but colourless when this is expelled. This liquid is very fluid; it evaporates almost instantaneously in the open air, affording white vapours, and leaving a little silica. It has a very penetrating odour, which may be compared to that of cyanogen. Thrown into water, it floats, then dissolves in it, and leaves some silica.

When silicium is heated in vapour of potassium, it takes fire, producing a compound of silicium and potassium. The iodide of potassium does not unite with silicium.

Silicium is neither dissolved nor acted upon by the sulphuric, nitric, and muriatic acids, nor even by the nitro-muriatic. But it dissolves rapidly even in the cold, in a mixture of nitric and fluoric acid, with disengagement of nitrous gas. Combustible silicium dissolves on digestion in water of caustic potash; but in its incombustible state it is not affected by the alkalis in the moist way.

Silicium, once insulated, combines very reluctantly with the metals. Its remarkable affinity for platinum is known, from the experiments of M. Boussingault; but it may be heated as often and as long as we please in a platinum crucible, without any combination taking place. But when we try to reduce silicium (from silica) by potassium, in a platinum crucible, the silicium penetrates deeply into the platinum, in the spot where the potassium presses.

100 parts of pure silicium, dried *in vacuo*, were heated with carbonate of soda. The mass, treated with muriatic acid, evaporated to dryness, and strongly heated, was then dissolved in water. It left silica coloured gray by charcoal, which being washed and ignited, became snow-white, and weighed 203·75 parts. A little silica was afterwards procured from the washings, making in all 205·25. Hence 100 parts of silicium had absorbed 105·25 of oxygen. In another experiment, 208 parts of silica were obtained from 100 of silicium. Hence silica consists of

Silicium,	48·5
Oxygen,	51·5
	100·0

The proportion which M. Berzelius inferred from the capacity of saturation of silica with the saline bases, was 50·3 oxygen to 49·7 silicium.

The number of atoms of oxygen in silica has not been determined. M. Berzelius is inclined to consider it as a tritoxide, and to call the atom of silicium 277 oxygen, being 100, or 2·77 oxygen = 1.

Silicium does not seem to belong to the metallic class of bodies, but rather resembles carbon and boron. Some philosophical methodists, says Berzelius, will consequently give it the name of silicon; but I regard this denomination as useless, since there is no true limit between the metals and the metalloids (such as boron and carbon). Carbon has the metallic lustre, and conducts electricity, and still it is not reckoned a metal. If silicium could be fused, it would possibly acquire the properties wanting in its pulverulent state. Uranium, in this form, can hardly be distinguished by its aspect from silicium; but when crystallized, it has the metallic lustre. Columbium and titanium approach also to silicium in their chemical properties. Finally, when the electrical relation of a body is regarded as its only decisive feature, it is indifferent whether we place a combustible body among the metals or not.—*Annales de Chim. et Phys.* xxvii. 337.

I have already mentioned, in treating of earths, that Mr. Smithson had ingeniously suggested, that silica might be viewed in many mineral compounds as acting the part of an acid. This, however, is a vague analogy, and cannot justify us in ranking silica with acid bodies.

When obtained by the process first described, silica is a white powder, whose finest particles have a harsh and gritty feel. Its sp. gr. is 2·66. It is fusible only by the hydroxygen blowpipe. The saline menstruum, formed by neutralizing its alkaline solution with an acid, is capable of holding it dissolved, though silica seems by experiment to be insoluble in water. Yet in the water of the Geyser spring a portion of silica seems to remain dissolved, though the quantity of alkali present appears inadequate to the effect. Silica exists nearly pure in transparent quartz or rock crystal. It forms also the chief constituent of flints. By leaving a solution of silica in fluoric acid, or in aqueous potash, undisturbed for a long time, crystals of this earth have been obtained. The solution in alkaline lixivia is called *liquor silicum*. Glass is a compound of a similar nature, in which the proportion of silica is much greater.

Mr. Kirwan made many experiments on the mutual actions of silica and the other earths, at high degrees of heat. The following are some of his results:

Proportions.	Heat.	Effects.
80 silica, 20 barytes,	150° Wedg.	A white brittle mass.
75 silica, 25 barytes,	150	A brittle hard mass, semitransparent at the edges.
66 silica, 33 barytes,	150	Melted into a hard somewhat porous porcelain.
50 silica, 50 barytes,	148	A hard mass, not melted.
20 silica, 80 barytes,	148	The edges were melted into a pale greenish matter, between a porcelain and enamel.
25 silica, 75 barytes,	150	Melted into a somewhat porous porcelain mass.
33 silica, 66 barytes,	150	Melted into a yellowish and partly greenish-white porous porcelain.

When the barytes exceeds the silica in the proportion of three to one, the fused mass is soluble in acids,—a circumstance recently applied with great advantage in the analysis of minerals which contain alkaline matter.

The habitudes of strontian with silica are nearly the same as those with barytes. Lime water added to the *liquor silicum*, occasions a precipitate which is a compound of the two earths. The following are Mr. Kirwan's results in the dry way:—

Proportions.	Heat.	Effects.
50 lime, 50 silica,	150° Wedg.	Melted into a mass of a white colour, semitransparent at the edges, and striking fire, though feebly, with steel: it was intermediate between porcelain and enamel.
80 lime, 20 silica,	156	A yellowish-white loose powder.
20 lime, 80 silica,	156	Not melted: formed a brittle mass.

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When exposed to the highest possible heat, magnesia and silica, in equal parts, melt into a white enamel.

Silica and alumina unite both in the liquid and dry way. The latter compound constitutes porcelain and pottery-ware.

Equal parts of lime, magnesia, and silica, melt, according to Achard, into a greenish-coloured glass, hard enough to strike fire with steel. When the magnesia exceeds either of the other two ingredients, the mixture is infusible; when the silica exceeds, the only fusible proportions were, 3 silica, 2 lime, 1 magnesia; and when the lime is in excess, the mixture usually melts in a strong heat. With mixtures of lime, alumina, and silica, a fusible compound is usually obtained when the lime predominates. The only refractory proportions were,

Lime,	2	3
Silica,	1	1
Alumina,	2	2

Excess of silica gives a glass or porcelain, but excess of alumina will not furnish a glass.

When, in mixtures of magnesia, silica, and alumina, the first is in excess, no fusion takes place at 150°; when the second exceeds, a porcelain may be formed; and 3 parts of silica, 2 magnesia, and 1 alumina, form a glass. From Achard's experiments it would appear that a glass may be produced by exposing to a strong heat, equal parts of alumina, silica, lime, and magnesia.

Other proportions gave fusible mixtures, provided the silica was in excess.

The mineral sommite, or nephelin, consists, according to Vauquelin, of 49 alumina + 46 silica. If we suppose it to consist of a prime equivalent or atom of each constituent, then that of silica would be 3; for 49 : 3·2 : : 46 : 3. But if we take Vauquelin's analysis of euclase for the same purpose, we have the proportion of silica to that of alumina as 35 to 22. Hence, 22 : 3·2 : : 35 : 5·09 the prime equivalent of silica, which is not reconcileable to the above number, though it agrees with that deduced from Sir H. Davy's experiments on silicon. I give these examples to show how unprofitable such atomical determinations are. See IRON and ACID (FLUOSILICIC).

SILK. See BLEACHING, and APPENDIX.

SILLIMANITE. A new mineral from Saybrook in Connecticut. Colour dark gray, passing into clove brown. It occurs in a vein of quartz, penetrating gneiss, crystallized in rhomboidal prisms, whose angles are about 106° 30′ and 73° 10′; the inclination of the base to the axis of the prism being about 113°. The sides and angles of the crystals are frequently rounded. In hardness it exceeds quartz; and in some specimens, topaz. Translucent in small fragments. Brittle. Fracture in the longer diagonal lamellar, brilliant. Cross fracture uneven and splintery. Sp. gr. 3·41. Infusible at the blow-pipe, even with borax. Acids have no action on it. Its constituents are,

Silica,	42·666
Alumina,	54·111
Oxide of iron,	1·999
Water,	0·510
Loss,	0·714
	100·000

SILVAN. Tellurium, so called by Werner.

SILVER is the whitest of all metals, considerably harder than gold, very ductile and malleable, but less malleable than gold; for the continuity of its parts begins to break when it is hammered out into leaves of about the hundred and sixty thousandth of an inch thick, which is more than one-third thicker than gold leaf; in this state it does not transmit the light. Its specific gravity is from 10·4 to 10·5. It ignites before melting, and requires a strong heat to fuse it. The heat of common furnaces is insufficient to oxidize it; but the heat of the most powerful burning lenses vitrifies a portion of it, and causes it to emit fumes; which, when received on a plate of gold, are found to be silver in the metallic state. It has likewise been partly oxidized by twenty successive exposures to the heat of the porcelain furnace at Sevres. By passing a strong electric shock through a silver wire, it may be converted into a black oxide; and by a powerful galvanic battery, silver leaf may be made to burn with a beautiful green light. Lavoisier oxidized it by the blowpipe and oxygen gas; and a fine silver wire burns in the kindled united stream of oxygen and hydrogen gases. The air alters it very little, though it is disposed to obtain a thin purple or black coating from the sulphurous vapours which are emitted from animal substances, drains, or putrefying matters. This coating, after a long series of years, has been observed to scale off from images of silver exposed in churches; and was found, on examination, to consist of silver united with sulphur.

There seems to be only one oxide of silver, which is formed either by intense ignition in an open vessel, when an olive-coloured glass is obtained; or by adding a solution of caustic barytes to one of nitrate of silver, and heating the precipitate to dull redness. Sir H. Davy found that 100 of silver combine with 7·3 of oxygen in the above oxide; and if we suppose it to consist of a prime equivalent of each constituent, we shall have 13·7 for the prime of silver. Silver leaf burned by a voltaic battery affords the same olive-coloured oxide.

The prime equivalent of silver seems to be 13·75, or 110 on the hydrogen scale.

Silver combines with chlorine, when the metal is heated in contact with the gas. This chloride is, however, usually prepared by adding muriatic acid or a muriate, to nitrate of silver. It has been long known by the name of *luna-cornea* or *horn-silver*, because though a white powder, as it falls down from the nitrate solution, it fuses at a moderate heat, and forms a horny-looking substance when it cools. It consists of 13·75 silver + 4·5 chlorine.

The sulphuret of silver is a brittle substance, of a black colour and metallic lustre. It is formed by heating to redness thin plates of silver stratified with sulphur. It consists of 13·75 silver + 2 sulphur.

Fulminating silver is formed by pouring lime water into the pure nitrate, and filtering, washing the precipitate, and then digesting on it liquid ammonia in a little open capsule. In 12 hours, the ammonia must be cautiously decanted from the black powder, which is to be dried in minute portions, and with extreme circumspection, on bits of filtering paper or card. If struck, in even its moist state, with a hard body, it explodes; and if in any quantity, when dry, the fulmination is tremendous. The decanted ammonia, on being gently heated, effervesces, from disengagement of azote, and small crystals appear in it when it cools. These possess a still more formidable power of detonation, and can scarcely bear touching even under the liquid. It seems to be a compound either of oxide of silver and ammonia, or of the oxide and azote. The latter is probably its true constitution, like the explosive iodide and chloride. The sudden extrication of the condensed gas is the cause of the detonation.

Silver is soluble in the sulphuric acid when concentrated and boiling, and the metal in a state of division.

The muriatic acid does not act upon it, but the nitric acid, if somewhat diluted, dissolves it with great rapidity, and with a plentiful disengagement of nitrous gas; which, during its extrication, gives a blue or green colour to the acid, that entirely disappears if the silver made use of be pure; if it contain copper, the solution remains greenish; and if the acid contain either sulphuric or muriatic acid, these combine with a portion of the silver, and form scarcely soluble compounds, which fall to the bottom. If the silver contain gold, this metal separates in blackish-coloured flocks.

The nitric acid dissolves more than half its weight of silver; and the solution is very caustic, that is to say, it destroys and corrodes animal substances very powerfully.

The solution of silver, when fully saturated, deposits thin crystals as it cools, and also by evaporation. These are called lunar nitre, or nitrate of silver. A gentle heat is sufficient to fuse them, and drive off their water of crystallization. In this situation the nitrate, or rather subnitrate, for the heat drives off part of the acid, is of a black colour, may be cast into small sticks in a mould, and then forms the lapis infernalis, or lunar caustic used in surgery. A stronger heat decomposes nitrate of silver, the acid flying off, and the silver remaining pure. It is obvious that, for the purpose of forming the lunar caustic, it is not necessary to suffer the salt to crystallize, but that it may be made by evaporating the solution of silver at once to dryness; and as soon as the salt is fused, and ceases to boil, it may be poured out. The nitric acid driven off from nitrate of silver is decomposed, the products being oxygen and nitrogen.

The sulphate of silver, which is formed by pouring sulphuric acid into the nitric solution of silver, is sparingly soluble in water; and on this account forms crystals, which are so small, that they compose a white powder. The muriatic acid precipitates from nitric acid the saline compound called luna-cornea, or horn-silver; which has been so distinguished, because, when melted and cooled, it forms a semitransparent and partly flexible mass, resembling horn. It is supposed that a preparation of this kind has given rise to the accounts of malleable glass. This effect takes place with aqua regia, which acts strongly on silver but precipitates it in the form of muriate, as fast as it is dissolved.

If any salt with base of alkali, containing the muriatic acid, be added to the nitric solution of silver, the same effect takes place by double affinity; the alkaline base uniting with the nitric acid, and the silver falling down in combination with the muriatic acid.

Since the muriatic acid throws down only silver, lead, and mercury, and the latter of these two is not present in silver that has passed cupellation, though a small quantity of copper may elude the scorification in that process, the silver which may be revived from its muriate is purer than can readily be obtained by any other means. When this salt is exposed to a low red heat, its chlorine is not expelled; and a greater heat causes the whole concrete either to rise in fumes, or to pass through the pores of the vessel. To reduce it, therefore, it is necessary that it should be triturated with its own weight of fixed alkali and a little water, and the whole afterwards exposed to heat in a crucible, the bottom of which is covered with soda; the mass of muriate of silver being likewise covered with the same substance. In this way the acid will be separated from the silver, which is reduced to its metallic state.

As the precipitate of muriate of silver is very perceptible, the nitric solution of silver is used as a test of the presence of muriatic acid in waters; for a drop of this solution poured into such waters will cause a very evident cloudiness. The solution of silver is also used by assayers to purify the nitric acid from any admixture of muriatic acid. In this state they call it precipitated aquafortis.

M. Chenevix found, that a chlorate of silver may be formed, by passing a current of chlorine through water in which oxide of silver is suspended; or by digesting phosphate of silver with hyperoxymuriate of alumina. It requires only two parts of hot water for its solution, and this affords, on cooling, small white, opaque, rhomboidal crystals. It is likewise somewhat soluble in alcohol. Half a grain, mixed with half as much sulphur, and struck or rubbed, detonates with a loud report and a vivid flash.

Compounds of silver with other acids are best formed by precipitation from its solution in nitric acid; either by the acid itself, or by its alkaline salts. Phosphate of silver is a dense white precipitate, insoluble in water, but soluble in an excess of its acid. By heat it fuses into a greenish opaque glass. Carbonate of silver is a white insoluble powder, which is blackened by light. The fluate and borate are equally soluble. Distilled vinegar readily dissolves the oxide of silver, and the solution affords long white needles, easily crystallized. See SALTS.

The precipitates of silver, which are formed by the addition of alkalis or earths, are all reducible by mere heat, without the addition of any combustible substance.

A detonating powder has been sold lately at Paris as an object of amusement. It is enclosed between the folds of a card, cut in two lengthwise; the powder being placed at one end, and the other being notched, that it may be distinguished. If it be taken by the notched end, and the other be held over the flame of a candle, it soon detonates, with a sharp sound and violent flame. The card is torn, and changed brown; and the part in contact with the composition is covered with a slight metallic coating, of a grayish-white colour.

This compound, which M. Descotils calls detonating silver, to distinguish it from the fulminating silver of M. Berthollet, may be made by dissolving silver in pure nitric acid, and pouring into the solution, while it is going on, a sufficient quantity of rectified alcohol: or by adding alcohol to a nitric solution of silver with considerable excess of acid.

In the first case, the nitric acid into which the silver is put must be heated gently, till the solution commences, that is, till the first bubbles begin to appear. It is then to be removed from the fire, and a sufficient quantity of alcohol to be added immediately, to prevent the evolution of any nitrous vapour. The mixture of the two liquors occasions an extrication of heat; the effervescence quickly recommences, without any nitrous gas being disengaged; and it gradually increases, emitting at the same time a strong smell of nitric ether. In a short time the liquor becomes turbid, and a very heavy, white, crystalline powder falls down, which must be separated when it ceases to increase, and washed several times with small quantities of water.

If a very acid solution of silver previously made be employed, it must be heated gently, and the alcohol then added. The heat excited by the mixture, which is to be made gradually, soon occasions a considerable ebullition, and the powder immediately precipitates.

It would be superfluous to remind the chemist, that the mixture of alcohol with hot nitric acid is liable to occasion accidents, and that it is consequently prudent to operate on small quantities.

This powder has the following properties: It is white and crystalline; but the size and lustre of the crystals are variable. Light alters it a little. Heat, a blow, or long continued friction, causes it to inflame with a brisk detonation. Pressure alone, if it be not very powerful, has no effect on it. It likewise detonates by the electric spark. It is slightly soluble in water. It has a very strong metallic taste.

Concentrated sulphuric acid occasions it to take fire, and is thrown by it to a considerable distance. Dilute sulphuric acid appears to decompose it slowly.

Process for separating Silver from Copper by Mr. Keir.

Put the pieces of plated metal into an earthen glazed pan; pour upon them some acid liquor, which may be in the proportion of eight or ten pounds of sulphuric acid to one pound of nitre; stir them about, that the surfaces may be frequently exposed to fresh liquor, and assist the action by a gentle heat from 100° to 200° of Fahrenheit's scale. When the liquor is nearly saturated, the silver is to be precipitated from it by common salt, which forms a muriate of silver, easily reducible by melting it in a crucible with a sufficient quantity of potash; and lastly, by refining the melted silver, if necessary, with a little nitre thrown upon it. In this manner the silver will be obtained sufficiently pure, and the copper will remain unchanged. Otherwise, the silver may be precipitated in its metallic state, by adding to the solution of silver a few of the pieces of copper, and a sufficient quantity of water to enable the liquor to act upon the copper.

Mr. Andrew Thomson, of Banchory, has recommended the following method of purifying silver, which he observes is equally applicable to gold. The impure silver is to be flatted out to the thinness of a shilling, coiled up spirally, and put into a crucible, the bottom of which is covered with black oxide of manganese. More of this oxide is then to be added, till the silver is completely covered, and all the spaces between the coils filled. A cover is then to be luted on, with a small hole for the escape of the gas; and after it has been exposed to a heat sufficient to melt silver, for about a quarter of an hour, the whole of the alloy will be oxidized. The contents of this crucible are then to be poured into a larger, into which about three times as much powdered green glass has been previously put; a cover luted on as before, to prevent the access of any inflammable matter; and the crucible exposed to a heat sufficiently strong to melt the glass very fluid. On cooling and breaking the crucible, the silver will be found reduced at the bottom, and perfectly pure.

Sulphur combines very easily with silver, if thin plates, imbedded in it, be exposed to a heat sufficient to melt the sulphur. The sulphuret is of a deep violet colour, approaching to black, with a degree of metallic lustre, opaque, brittle, and soft. It is more fusible than silver, and this in proportion to the quantity of sulphur combined with it. A strong heat expels part of the sulphur.

Sulphuretted hydrogen soon tarnishes the surface of polished silver, and forms on it a thin layer of sulphuret.

The alkaline sulphurets combine with it by heat, and form a compound soluble in water. Acids precipitate sulphuret of silver from this solution.

Phosphorus left in a nitric solution of silver becomes covered with the metal in a dendritic form. By boiling, this becomes first white, then a light black mass, and is ultimately converted into a light brown phosphuret. The best method of forming a phosphuret of silver is Pelletier's, which consists in mixing phosphoric acid and charcoal with the metal, and exposing the mixture to heat.

Most metallic substances precipitate silver in the metallic state from its solution. The assayers make use of copper to separate the silver from the nitric acid used in the process of parting. The precipitation of silver by mercury is very slow, and produces a peculiar symmetrical arrangement, called the tree of Diana. In this, as in all precipitations, the peculiar form may be affected by a variety of concomitant circumstances; for which reason one process usually succeeds better than another.

Make an amalgam, without heat, of four drachms of leaf silver with two drachms of mercury. Dissolve the amalgam in four ounces or a sufficient quantity of pure nitric acid of a moderate strength; dilute this solution in about a pound and a half of distilled water; agitate the mixture, and preserve it for use in a glass bottle with a ground stopper. When this preparation is to be used, the quantity of one ounce is put into a phial, and the size of a pea of amalgam of gold, or silver, as soft as butter, is to be added; after which the vessel must be left at rest. Soon afterwards, small filaments appear to issue out of the ball of amalgam, which quickly increase, and shoot out branches in the form of shrubs.

Silver unites with gold by fusion, and forms a pale alloy, as has been already mentioned in treating of that metal. With platina it forms a hard mixture, rather yellower than silver itself, and of difficult fusion. The two metals do not unite well. Silver melted with one-tenth part of crude platina, from which the ferruginous particles had been separated by a strong magnet, could not be rendered clear of scabrous parts, though it was repeatedly fused, poured out, and laminated between rollers. It was then fused, and suffered to cool in the crucible, but with no better success. After it had been formed, by rolling and hammering, into a spoon for blowpipe experiments, it was exposed to a low red heat, and became rough and blistered over its whole surface. The quantities were one hundred grains of silver, and ten grains of platina. Nitre was added during the fusions.

Silver very readily combines with mercury. A very sensible degree of heat is produced when silver leaf and mercury are kneaded together in the palm of the hand. With lead it forms a soft mass, less sonorous than pure silver. With copper it becomes harder and more sonorous, at the same time that it remains sufficiently ductile: this mixture is used in the British coinage. 12⅓ parts of silver, alloyed with one of copper, form the compound called standard silver. The mixture of silver and iron has been little examined. With tin it forms a compound, which, like that of gold with the same metal, has been said to be brittle, however small the proportion; though there is probably as little foundation for the assertion in the one case as in the other. With bismuth, arsenic, zinc, and antimony, it forms brittle compounds. It does not unite with nickel. The compound of silver and tungsten, in the proportion of two of the former to one of the latter, was extended under the hammer during a few strokes; but afterwards split in pieces. See Iron.

The uses of silver are well known: it is chiefly applied to the forming of various utensils for domestic use, and as the medium of exchange in money. Its disposition to assume a black colour by tarnishing, and its softness, appear to be the chief objection to its use in the construction of graduated instruments for astronomical and other purposes, in which a good white metal would be a desirable acquisition. The nitrate of silver, besides its great use as a caustic, has been employed as a medicine, it is said with good success, in epileptic cases, in the dose of 1-20th of a grain, gradually increased to 1-8th, three times a-day. Dr. Cappe gave it in a dose of 1-4th of a grain three times a-day, and afterwards four times, in what he supposed to be a case of angina pectoris, in a stout man of sixty, whom he cured. He took it for two or three months. Dr. Cappe imagines that it has the effect of increasing the nervous power, by which muscular action is excited.

The frequent employment in chemical researches of nitrate of silver as a reagent for combined chlorine, occasions the production of a considerable quantity of the chloride (muriate) of silver, which is usually reconverted into metal by fusion with potash in a crucible. But, as much of the silver is lost in this way, it is better to expose the following mixture to the requisite heat:

Chloride of silver,	100
Dry quicklime, . .	19·8
Powdered charcoal, .	4·2

An easier method, however, is to put the metallic chloride into a pot of clean iron or zinc, to cover it with a small quantity of water, and to add a little sulphuric or muriatic acid. The reduction of the chloride of silver by the zinc or iron is an operation which it is curious to observe, especially with the chloride in mass (*luna-cornea*). It begins first at the points of contact, and speedily extends in the form of ramifications, over its whole surface, and into its interior. Hence, in less than an hour, considerable pieces of horn-silver are entirely reduced. If the mass operated on be considerable, the temperature rises, and accelerates the revivification. On the small scale, artificial heat may be applied. —*Ann. de Chimie, July*, 1820. See Salts.

SILVERING. There are various methods of giving a covering of silver or silvery aspect to the surfaces of bodies. The application of silver leaf is made in the same way as that of gold, for which see Gilding.

Copper may be silvered over by rubbing it with the following powder: Two drachms of tartar, the same quantity of common salt, and half a drachm of alum, are mixed with fifteen or twenty grains of silver precipitated from nitric acid by copper. The surface of the copper becomes white when rubbed with this powder, which may afterward be brushed off and polished with leather.

The saddlers and harness-makers cover their wares with tin for ordinary uses, but a cheap silvering is used for this purpose as follows: Half an ounce of silver that has been precipitated from aquafortis by the addition of copper, common salt, and muriate of ammonia, of each two ounces, and one drachm of corrosive muriate of mercury, are triturated together, and made into a paste with water; with this, copper utensils of every kind, that have been previously boiled with tartar and alum, are rubbed, after which they are made red-hot, and then polished. The intention of this process appears to be little more than to apply the silver in a state of minute division to the clean surface of the copper, and afterward to fix it there by fusion; and accordingly this silvering may be effected by using the argentine precipitate here mentioned, with borax or mercury, and causing it to adhere by fusion.

The dial-plates of clocks, the scales of barometers, and other similar articles, are silvered by rubbing upon them a mixture of muriate of silver, sea salt, and tartar, and afterward carefully washing off the saline matter with water. In this operation, the silver is precipitated from the muriatic acid, which unites with part of the coppery surface. It is not durable, but may be improved by heating the article, and repeating the operation till the covering seems sufficiently thick.

The silvering of pins is effected by boiling them with tin filings and tartar.

Hollow mirrors or globes are silvered by an amalgam, consisting of one part by weight of bismuth, half a part of lead, the same quantity of pure tin, and two parts mercury. The solid metals are to be first fused together, and the mercury added when the mixture is almost cold. A very gentle heat is sufficient to fuse this amalgam. In this state it is poured into a clean glass globe intended to be silvered, by means of a paper funnel, which reaches to the bottom. At a certain temperature, it will stick to the glass, which by a proper motion may thus be silvered completely, and the superfluous amalgam poured out. The appearance of these toys is varied by using glass of different colours, such as yellow, blue, or green.

SKORODITE. Colour leek-green. Massive, but generally crystallized in very short broad rectangular four-sided prisms. Fracture uneven. Translucent. As hard as calcareous spar. Easily frangible. It melts before the blowpipe, with emission of arsenical vapour, and is converted into a reddish-brown mass, which, when highly heated, so as to drive off all the arsenic, becomes attractible by the magnet. It is an arseniate of iron, without copper. It occurs in quartz and hornstone, in primitive rocks, in the Schneeberg mining district in Saxony.

SLATE (ADHESIVE). See Clay.

SLATE CLAY. See Clay.

SLATE COAL. See Coal.

SLATE SPAR, or SCHIEFER SPAR. A sub-species of limestone.

SLICKENSIDES. The specular variety of Galena, so called in Derbyshire. It expresses the smoothness of its surface. It occurs lining the walls of very narrow rents. It has a most remarkable property, that when the rock in which it is contained is struck with a hammer, a crackling noise is heard, which is generally followed by an explosion of the rock, in the direction and neighbourhood of the vein. The cause of this singular effect has not been satisfactorily explained.—*Jameson.*

SMALT. See Zaffre.

SMARAGDITE. Diallage.

SMARAGDUS. See Emerald.

SOAP. A compound, in definite proportions, of certain principles in oils, fats, or resin, with a salifiable base. When this base is potash or soda, the compound is used as a detergent in washing clothes. When an alkaline earth, or oxide of a common metal, as litharge, is the salifiable base, the compound is insoluble in water. The first of these combinations is scarcely applied to any use, if we except that of linseed-oil with lime-water, sometimes prescribed as a liniment against burns; and the last is known only in surgery as the basis of certain plasters. Concerning the chemical constitution of soaps and saponification, no exact ideas were entertained prior to M. Chevreul's researches; of which copious details are given under the articles Fat, Elaïn, Acids (Margaric and Oleic).

Fats are compounds of a solid and a liquid substance; the former called *stearine*, the latter resembling vegetable oil, and therefore called *elaïne.* When fat is treated with a hot ley of potash or soda, the constituents react on one another, so as to generate the solid pearly matter *margaric acid*, and the fluid matter *oleic acid*, both of which enter into a species of saline combination with the alkali; while the third matter that is produced, the *sweet principle*, remains free. We must therefore regard our common soap as a mixture of an alkaline margarate and oleate, in proportions determined by the relative proportions of the two acids producible from the peculiar species of fat. It is probable, on the other hand, that the soap formed from vegetable oil is chiefly an *oleate.* No chemical researches have hitherto been made known, on the compounds of resin with alkalis, though these constitute the brown soaps so extensively manufactured in this country. All oils or fats do not possess in an equal degree the property of saponification. Those which saponify best, according to D'Arcet, senior, Lelievre, and Pelletier, are,

1. Oil of olives, and of sweet almonds.
2. Animal oils; as hog's-lard, tallow, butter, and horse-oil.
3. Oil of colza, or rape-seed oil.
4. Oil of beech-mast and poppy-seed, when mixed with olive-oil or tallow.
5. The several fish-oils, mingled like the preceding.
6. Hempseed-oil.
7. Nut oil and linseed-oil.
8. Palm-oil.
9. Rosin.

In general, the only soaps employed in commerce, are those of olive-oil, tallow, lard, palm-oil, and rosin. A species of soap can also be formed by the union of bees-wax with alkali; but this has no detergent application, being used only for painting in *encausto.*

I shall first describe the fabrication of olive-oil soap: To this oil there is usually added one-fifth of that of rape-seed; without which addition the section of the soap would not be sufficiently smooth and uniform, but clotty, parts of elaine, and 28 of stearine; while 100 parts of rape-seed oil consist of 54 elaïne, and 46 of stearine. Since, however, the prime equivalents of the margaric and oleic acids, which result from the above two principles, are nearly the same, that of the former being about 34, and of the latter 36, it does not seem necessary to consider, in a chemical point of view, the proportions of the two oils.

Besides the oils, the matters employed in the manufacture of this soap are, 1*st*, the soda (barilla) of commerce, of good quality, that is, containing from 30 to 36 per cent. of dry carbonate; 2*d*, quicklime; 3*d*, water. 100 parts of oil require about 54 parts of the best barilla for saponification; and 3 parts of the barilla require 1 of quicklime.

After bruising the soda, and slacking the lime, they are mingled, and a certain quantity of cold water is poured upon the mixture. At the end of 12 hours, the liquor is allowed to run off. It is called the first ley, and marks from 20° to 25° on the hydrometer of Baumé, (sp. gr. 1·16 to 1·21). On treating the residuum twice with fresh water to exhaust it, two other leys are obtained; the one from 10° to 15°, (sp. gr. 1·072 to 1·114); the other from 4° to 5°, (sp. gr. 1·027 to 1·036).

When the manufacturer has laid in a stock of leys, of different densities, he engages in the soap-boiling. For this purpose, he employs boilers (caldrons) which vary much in their construction, and which may contain from 5000 to 2500 pounds of soap. In all cases, they have at their bottom a pipe 2⅜ inches in diameter, called the thorn (*epine*).

They begin by putting weak ley into the boiler; they then pour in gradually the oil, and boil the mixture. The combination is soon effected, forming a species of emulsion: they temper the fire, and add successively weak ley and oil, taking care to maintain the mass in a homogeneous pasty state, without ley at the bottom or oil on the surface, in order to accelerate the combination.

When they have thus put into the boiler all the oil which they wish to saponify, they add to it slowly some strong ley, which completes the saturation of the oil, converting the emulsion, with an oily excess, into a perfect soap, which separates from the ley, and which collects upon the surface.

Whenever this phenomenon occurs, the ley, although very abundant, is no longer fit for saponification; there is now present in it only some neutral salts, carbonate of soda, and a little caustic soda, unabsorbed. For this reason, when the fire has been allowed to fall, they withdraw the ley by the pipe, so as to leave the soap nearly dry. Fresh leys are now added, which are caustic and concentrated; and the fire is rekindled. Thus there is poured into the boiler more caustic ley than is required to alkali, and the ebullition is stopped when the ley has attained a specific gravity of 1·15 or 1·2. This ley, over which the soap floats, is next withdrawn, like the preceding, and the soap is left dry at the bottom of the boiler. In this state, the soap is of a deep blue colour bordering on black, and contains only 16 *per cent.* of water. This colour proceeds from a combination of the oil, alumina, and hydrosulphuret of iron, which is formed during the pasty process, and which dissolves in the soap. The alumina is derived from the furnaces in which the soda is fabricated, and gets dissolved in it during the lixiviation. The sulphuretted hydrogen comes from the hydrosulphuret of soda contained in the ley, and is set at liberty the moment that the paste or glue is made. As to the oxide of iron, it proceeds from the materials employed, or from the hearth of the furnace, or from the plant itself, when native barilla is employed. This oxide of iron is held in solution by the hydrosulphuret of soda. When the leys do not contain enough of oxide of iron to colour the aluminous soap into a fine blue, they add to the boiling a sufficient quantity of iron, which is done by sprinkling in a solution of copperas, after the pasty operation. At any rate, it appears that the oil unites almost immediately with the alumina and the oxide of iron; that there thence results a yellowish alumino-ferruginous soap, and that it is only by the heat of ebullition that this soap acquires the blue colour. The soap made by the above process may be converted either into white or marbled soap. To convert it into white soap, we must mingle it gradually with dilute leys, with a gentle heat, and allow deposition to take place, with a covered boiler. The blackish alumino-ferruginous soap, not being soluble in the soda-soap at this temperature, separates from it, and falls to the bottom of the boiler.

The soap-paste, which has become perfectly white, is now taken out, and run into the wooden frames, where it becomes hard on cooling. From these it is finally removed, and cut into bars.

This soap is known in France under the name of soap in tables, (*savon en table*.) According to M. Thenard, it consists of,

Soda, . .	4·6
Fat matter, .	50·2
Water, . .	45·2
	100·0

According to M. D'Arcet's analysis, as reported to me by M. Clement, Marseilles white soap is composed of,

Soda, . .	6
Oil, . . .	60
Water, . . .	34
	100

By my experiments on that soap, the quantity of soda in it is from 6 to 6·5 *per cent.*

This soap is preferred for delicate purposes; as the washing of lace, and for dyeing; because, having been edulcorated with very weak leys, and purified by subsidence and decantation, it contains no excess of alkali, nor any foreign body. It is hence much smoother and milder than the marbled soap, of which we are now to treat.

When the soap-boiling is finished, and when the ley over which it swims has acquired a specific gravity of from 1·15 to 1·20, the soap is of a blackish-blue colour, as we have said above. In this state, if, instead of wishing to make *table soap*, we desire to make the marbled kind, we pursue the following plan:—

We have seen that the soap contains then but 16 per cent. of water, and that the entire mass has a dark colour. We must add water to supply the deficiency, in order that the colouring matters be separated from the white paste, and that it may unite into veins of greater or less size, so as to form a species of blue marbling, in a white basis. The separation of this body may be compared to a species of crystallization. For its proper production, the soap must be suitably diluted, and it must not be allowed to cool either too slowly or too quickly. If it be too much diluted, and if it cool too slowly, we obtain only a white soap, the whole marbling falling to the bottom. In the opposite case, it is entirely in little grains, like a mass of granite.

This process is founded, we perceive, on the smaller solubility of the alumino-ferruginous soap, at a low temperature; and on the property which the solution possesses of not being able to retain it, and of separating from it at a certain density.

At all events, whenever there is added to the *boiling* a suitable quantity of weak ley, to bring it to the desired point, this soap is run into the frames in the same way as the white soap, and is taken out after cooling to be cut into bars. The frames or boxes for cooling the soap are either wooden boxes with moveable sides fixed by wedges, or are stone troughs jointed with cement. The platform on which they rest must be so constructed, as to allow the ley to run off into a reservoir. This mottled soap is always harder and more uniform in its proportions than the white table-soap. In fact, the production of the marbling does not permit the manufacturer to vary the quantity of the water; for this depends on the marbling. White table-soap, on the contrary, may receive as much water as the manufacturer shall desire, and it is even whiter the more water it contains. It thence appears, that the marbled soap deserves a preference.

Some years ago, I analyzed the foreign Castile soap, as also an imitation of it made in London. The first had a specific gravity of 1·0705. It consisted of,

Soda,	9·0
Well-dried oily matter,	76·5
Water with a little colouring matter,	14·5
	100·0

The specific gravity of the second was only 0·9669; for it remained at rest in any part of a dilute alcohol of that density. Its composition was,

Soda,	10·5
Pasty consistence and fat,	75·2
Water with the colouring matter,	14·3
	100·0

The difference of density probably arose partly from a higher specific gravity of the oil, and partly from the greater chemical condensation of the soapy particles in the foreign marbled soap, usually called Castile soap by the apothecaries. Both of the above soaps were very dry.

Berry's white soap yielded me,

Soda,	8
Fatty matter,	75
Water,	17
	100

Glasgow best white soap,

Soda,	6·4
Tallow,	60·0
Water with a little muriate of soda,	33·6
	100·0

Brown or rosin-soap, (Glasgow),

Soda,	6·5
Rosin and fat,	70·0
Water,	23·5
	100·0

I have since examined several of the common white soaps. The average of soda *per cent.* is about 5, from which their detergent quality may be inferred to be considerably inferior to the preceding soaps, which were all carefully manufactured. The soap lately imported from India, when freed from the soda powder on its surface, yields less than 5 per cent. of combined soda, and is hence not so powerful a detergent as many of the common soaps of this country. It is, moreover, highly charged with muriate of soda. The composition of a good soft, or potash soap, made by a respectable manufacturer in Glasgow, was as follows:—

Potash,	9
Fat,	43·7
Water,	47·3
	100·0

Here the equivalent proportions are no longer observed. As we may estimate the mean atomic weight of the oleic and margaric acids at 35, or ten times that of lime (oxygen being 1), we see that 9 of potash should take 52·5 of fat, instead of 43·7. 6 of soda (equivalent to 9 of potash) in a hard soap will indicate in like manner 52·5 of fat. I consider this proportion to be that of good soap, such as the best Marseilles; but we shall generally find, I believe, somewhat less than 5 in 100 parts of our soaps of commerce, sometimes only 4·5; and hence such soaps may be estimated at

Soda, ...	5·00	or	4·5
Fat, ...	43·75		39·4
Water and muriate of soda,	51·25		56·1
	100·00		100·0

There are debased soaps, however, of which the pretended snow-soap is the most remarkable, that contain far less of the real saponified compound than the above. It is the practice of some persons to keep the soap in strong brine, after it has been charged with a large dose of common salt. Such adulterations should be detected, and their authors exposed. My alkalimeter, noticed in the introduction, will enable any person, however little skilled in chemistry, to ascertain in a few minutes the detergent or washing quality of any soap.

The specific gravity of soap is in general greater than that of water. Its taste is faintly alkaline. When subjected to heat, it speedily fuses, swells up, and is then decomposed. Exposed to the air in thin slices, it soon becomes dry; but the whole combined water does not leave it, even by careful desiccation on a sandbath. Thus 100 parts of Berry's cake soap, analyzed above, loses only 12 per cent.; and 100 of the best Glasgow white soap, only 21. If we suppose good hard soap to consist of 1 prime soda, 1 prime saponified fat, and 20 primes water, we shall have its theoretic composition to be—

Soda, . .	4	6·5
Fat, . .	35	56·9
Water, . .	22·5	36·6
	61·5	100·0

This is probably the true constitution, which may be occasionally modified by the formation of a little suboleate or submargarate, and a slight variation in the quantity of water, either from evaporation, or the presence of a little in excess, not chemically combined. When such soap is desiccated, if it still retains 10 atoms of intimately combined water, the proportion of this *per cent.* will be 22, nearly coinciding with the last of the above results.

Soap is much more soluble in hot than in cold water This solution is instantly disturbed by the greater number of acids, which seizing the alkali, either separate the fatty principles, or unite with them into an acido-soapy emulsion. The solution is likewise decomposed by almost all the earthy and metallic salts, which give birth to insoluble compounds of the oleic and margaric acids with the salifiable bases.

Soap is soluble in alcohol; and in large quantity by the aid of heat. When boiling alcohol is saturated with soap, the liquid, on cooling, forms a consistent transparent mass of a yellow colour. When this mass is dried, it still retains its transparency, provided the soap be a compound of tallow and soda; and in this state it is sold by the perfumers in this country.

Good soap possesses the property of removing from linen and cloth the greater part of fatty substances which may have been applied to them.

With regard to marbled soaps, M. Chaptal, in his *Chimie Appliquée*, says, that it is not till after two days' boiling, that the process of variegation is begun. With this view $\frac{1}{25}$ part of the sulphate of iron, relatively to the oil intended for saponification, is diluted, and decomposed with a weak lixivium. This solution (mixture) is then poured into the caldron, which is kept in a state of ebullition till the paste becomes black; after which the fire is extinguished, and the lixivium which remains unincorporated is drawn off. When this is done, they rekindle the fire, and supply the paste with ley during 24 hours; after which the fire being put out, the matter is left to settle, and the lixivium drawn off as before. This process is repeated for eight or nine days, at the end of which the fire is removed, and the lixivium evacuated. As soon as the mass has settled, about 12 pounds avoirdupois of *Spanish-brown* diffused through water are added to it. When this is done, two workmen, stationed on boards set over the caldron, and furnished with long poles, to the extremity of each of which is attached a board about ten inches square, raise up the paste, and agitate it in different directions, while others pour lixivium in at intervals, till the paste be rendered fluid. After this operation the soap is removed into the moulds.

The description of the marbling process previously given is taken from Thenard, and seems to me more correct, though the above manipulations are no doubt worthy of attention.

We ascertain that soap has attained a due degree of consistence, 1. By allowing a small portion of it to fall and coagulate on a slate. 2. If on shaking a spatula, which has been dipped into the paste, briskly in the air, the soap be detached in the form of ribbons, without adhering to the wood. 3. By the peculiar odour of soap, and by handling it between the fingers. At the stage of saponification, when the paste is becoming stiff, and beginning to separate from the aqueous liquor, Messrs. Pelletier, D'Arcet, and Lelievre, advise us, at this period, to throw into the caldron a few pounds of sea-salt, in order to produce a more complete separation; the paste then assumes a grained form, somewhat resembling spoiled cream; the ebullition is maintained during two hours, after which the fire is withdrawn, and the agitation discontinued. When a few hours have elapsed, the liquor which has subsided to the bottom of the caldron is drawn off by means of the pipe; the fire is rekindled, the soap is dissolved by the aid of a little water poured into the caldron, the mixture is agitated, and when it is completely liquefied, and in a boiling state, the remainder of the first ley (about 1·14 sp. gr.) is gradually added to it. In some manufactures, says M. Chaptal, the strongest lixivium (the first) is employed at the commencement of the ebullition; by which method the paste becomes quickly thickened to a considerable degree, and requires to be managed by persons skilled in such operations. It is judged necessary to pour in fresh ley when the paste sinks down, and remains at rest. They continue to employ the strong ley till it be nearly exhausted. Then the boiling subsides, that is, it sinks down, and appears as if stationary. It boils in this quiet manner during three or four hours; after which it is moistened by pouring into it the second lixivium (1·072 to 1·089 sp. gr.), while care is at the same time taken progressively to augment the heat. It very rarely happens, when the strongest lixivium has been used at the beginning, that the third ley (1·027 to 1·04 sp. grav.) is necessary. This is employed only when the paste does not boil, because then the object is to dilute it. As soon as the boiling is finished, the fire is withdrawn; the lixivium is then drawn off; after which the paste is left to cool, and taken up before it be fully coagulated, by means of copper, or wooden buckets, to be transferred into moulds, into the bottoms of which a portion of pulverized lime has been previously introduced, to prevent the soap from adhering to them. At the end of two or three days, when the soap has become sufficiently hard, they remove it from the mould, and divide it into wedges of different sizes by means of a brass wire. They place these wedges on a floor edgeways, where they are allowed to remain till they become perfectly firm and dry.

The fair trader, adds M. Chaptal, lays his account with procuring five pounds of soap from three pounds of oil. The soap is not marketable till it ceases to receive any impression from the fingers.

It must not be supposed that the lixivium employed at the commencement of the process should be constantly continued. The great art of soap-making consists in knowing to determine, from the appearance of the paste and other circumstances, what kind of lixivium should be employed during each step of the operation. The overseers regulate their conduct in this respect by observation and experience. The form and size of the bubbles, the colour of the paste, the volume of that which is thrown out on the edges of the vessel, the consistence of the matter, and its disposition to swell, as well as the appearance of the steam, all furnish them with *criteria* by which to regulate their conduct.

It sometimes happens, that the paste, though apparently very firm, yet when set in the cold air to concrete, throws out much water, and is resolved into small grains possessing little consistency. In this case it is evident that the ley is in excess, and must be dissipated by heat, or precipitated (separated) by means of marine salt. Frequently, also, the paste becomes *greasy*, and the oil appears to separate from the soda. As this in general proceeds from the paste not being imbued with sufficient water to keep it in combination, it is necessary to add to it a portion of water, or very weak lixivium, to remedy this defect.

The adulterations most commonly practised on soap are the following:—

When the soap is made, they add to it much water, which renders it white. Frequently pulverized lime, gypsum, or pipe-clay are incorporated with it. The former of these frauds is readily discovered by the rapid loss of weight which the soap suffers on exposure to a dry air; the second can be easily detected by solution in alcohol, when the earthy matters fall down.

Hard soap is made in Scotland chiefly with kelp and tallow. That crude alkali rarely contains more than from one to five per cent. of free soda, mixed with some sulphate and hydrosulphite, and nearly 33 per cent. of muriate of soda. To every ton of kelp broken into small fragments, about 1-6th of new slacked lime is added. The whole, after mixture, are put into a large tub called a cave, having a perforation at the bottom, shut with a wooden plug. Upon the materials, water is very slowly poured. The liquid, after digestion, is suffered to run slowly off into a reservoir sunk in the ground. The first portion, or ley No. 1. is of course the strongest, and is reserved for the last operation in soap-boiling. I find that a gallon of that of average strength contains 1000 grains of real soda, so that one pound of the alkali is present in seven gallons of the ley. The second portion run off contains 800 grains in 1 gallon, equivalent to a pound in 8¾ gallons. The third contains 600 grains per gallon, or 1 pound in 11⅔ gallons; and the fourth, 200 grains, or 1 pound in 35 gallons. The last is not employed directly, but is thrown on a fresh mixture in the cave, to acquire more alkaline strength.

Six days are required to make one boiling of soap, in which two tons or upwards of tallow may be employed. The leys, 2. and 3.

mixed, are used at the beginning, diluted with water, on account of the excess of sea-salt in the kelp. A quantity of ley, not well defined, is poured on the melted tallow, and the mixture is boiled, a workman agitating the materials to facilitate the combination. The fire being withdrawn, and the aqueous liquid having subsided, it is pumped off, and a new portion is thrown in. A second boil is given, and so on in succession. 2 or 3 boils are performed every 12 hours, for 6 days, constituting 12 or 18 operations in whole. Towards the last, the stronger ley is brought into play. Whenever the workman perceives the saponification perfect, the process is stopped; and the soap is lifted out, and put into the moulds.

When the price of American potash is such as to admit of its economical employment, a ley of that alkali, rendered caustic by lime, is used in the saponification, and the soft potash soap which results is converted into a hard soda soap, by double decomposition. This is effected either by the addition of common salt, or rather of a kelp ley; which supplies abundance of muriate of soda. The muriatic acid goes to the potash, to constitute muriate of potash, which dissolves in the water, and is drawn off in the spent ley; while the soda enters into combination with the fat, (or rather the margaric and oleic acids, now evolved), and forms a soap, which becomes solid on cooling. A weak potash ley is used at first, and subsequently one of greater strength. I have found the potash ley of a respectable manufacturer to contain 3000 grains of real potash per gallon; which is equivalent to 1 pound of real alkali in 2⅓ gallons. But I cannot offer this proportion as any standard; for practical soap-boiling is, in regard to the alkaline strength of the leys, in a deplorable state of darkness and imperfection. To this cause chiefly we may ascribe the perpetual disappointments which occur in the soap manufactories.

Two tons of tallow, properly saponified, should yield fully 3 tons of marketable white soap. But I have known a manufacturer produce only 2½ tons, by some ridiculous mismanagement of his leys. The sulphuretted hydrogen present in the crude alkalis, gives a blue stain to the soap. This may be removed, in a great measure, by contact of air. But the proper plan would be, to employ an alkali previously deprived as much as possible of its sulphur. Those who decompose sulphate of soda, with the view of using the alkali in saponification, are liable to many accidents from the above cause. Much balsam of sulphur is formed, at the expense of the soap; and the manufactured article is generally inferior in detergent powers to the kelp soap, which, however, is by no means so free from sulphur as it might be made, previous to its employment, by simple methods, which would at the same time double its alkaline powers.

For brown or yellow soap, a mixture of tallow and rosin, with a little palm oil to improve the colour, is used. Soap of the coarser quality is made with equal parts of rosin and tallow. But that of better quality requires 3 parts of tallow to 1 of rosin; and for every ton of that mixture, half a hundred weight of palm oil. The rosin soaps consume less alkaline ley than those with fat alone.

Soft Soaps. The compounds of fats or oils with potash remain soft, or at least pasty. Three kinds of these are known in commerce; the soaps from rape-seed, and other oleaginous seeds, called *green soaps*; *toilette soaps*, made with hog's lard; and common soft soaps, made with fish oils.

Manufacturers of green soap prepare their potash leys as those of hard soap do their soda leys, and conduct their operations in the same manner till the whole oils be added. In this state the soap resembles an unguent. It contains excess of oil, is white, and hardly transparent. After tempering the fire, they keep stirring continually the bottom of the caldron with large spatulas; they then add, by degrees, new leys perfectly caustic, and somewhat stronger than the first. The saturation of the oil is thus effected, and the soap becomes transparent. The fire is now continued to give the soap a suitable consistency, after which it is run off into barrels to be offered for sale.

We perceive that this species of soap differs considerably from the soap manufactured with olive oil and soda. Here, from the commencement of the operation to its end, the art of the soap-boiler consists in effecting the combination of the oil with the potash, without the soap ceasing to be dissolved in the ley; whilst in the fabrication of hard soap it is necessary, on the contrary, as we have seen, to separate the soap from the ley, even before the saturation of the oil is accomplished.

Green soap contains, in general, more alkali than is absolutely necessary for the saturation of the oil. It is, in fact, a perfect soap, dissolved in an alkaline ley. It should be transparent, of a fine green colour; a shade sometimes produced by means of indigo. According to M. Thenard, it is usually composed of

Potash, -	9.5
Fatty matter, -	44.0
Water, -	46.5
	100.0

This soft soap may be readily converted into hard soap, as we have stated above, by the addition of muriate of soda.

Toilette soaps, made with hog's lard and potash, should have as small an alkaline excess as possible. The finer soaps for the toilette are made with oil of sweet almonds, with nut oil, palm oil, suet, or butter. They are either potash or soda soaps, as they may be preferred in the pasty or solid state.

The following facts from Chaptal, on soft soaps, are worthy of insertion. After introducing into the caldron the half of the oil intended for one coction, the fire is kindled, and when the oil begins to grow hot, we add to it a portion of the potash lixivium. The remainder of the oil and lixivium must afterwards be gradually poured in during the ebullition. If too much of the lixivium be employed at the commencement, no combination takes place; if the lixivium be too strong, the mixture separates into clots; and if it be too weak, the union is incomplete. The quantity of the ley employed in one coction ought to be in the proportion of 4 parts to 3 of oil. 200 parts of oil, and 125 of potash, yield 325 of soap. When the union is fully accomplished, and the liquor rendered transparent, nothing remains but to employ the necessary degree of coction. The soap-boilers judge of the degree of coction by the consistency, by the colour, and from the time which the soap takes to coagulate. In order to make the froth subside, and render the mass fit for barrelling, one ton of soap (ready made?) is emptied into the caldron. The soap held in the greatest request is of a brown colour, inclining to black. The manufacturers in Flanders dye the soap, by throwing into the caldron, half an hour before the termination of the boiling or coction, a composition of one pound of the sulphate of iron, half a pound of galls, and an equal quantity of red wood; and boiling it with the lixivium.

When the soap is prepared with a great portion of *warm* or *yellow oil*, a green colour may be imparted to it, by pouring into the ley a solution of indigo. This soap is reckoned of the best quality: it remains always in the state of a soft paste, on which account it is placed in casks as expeditiously as possible.

Since writing the above, I have learned the following particulars on the manufacture of soft soap, from an eminent soap-boiler, near Glasgow:—

273 gallons of whale or cod oil, and 4 cwt. of tallow, are put into the boiler, with 252 gallons of potash ley, whose alkaline strength I find to be such, that one gallon contains 6600 grains of real potash. Heat is applied, when the mixture froths up very much, but is prevented from boiling over by the wooden crib, which surmounts the iron caldron. If it now subside into a doughy magma, the ley has been too concentrated. It should have a thin gluey aspect. There are next poured in, two measures of a stronger ley, holding each 21 gallons, (containing per gallon 8700 gr. real potash), and after a little interval other two measures, and so on progressively, till 14 measures have been added in whole. After suitable boiling, without agitation, the soap is formed, amounting in all to 100 firkins of 64 lbs. each, from the above quantity of materials. The manufacture of soft soap is reckoned more difficult and delicate than that of hard soap. Rape oil forms a hard soap, neither so consistent nor so white as that from olive oil. Hempseed oil produces a green-coloured soap, reducible to a paste by a small portion of water. The soaps prepared with oils procured from beech-mast and clove July-flowers, are of a clammy glutinous consistence, and generally of a grayish-colour. Nut oil forms a soap not proper for the hands; it is of a yellowish-white colour, of a moderate degree of consistence, unctuous, gluey, and continues so on exposure to the air. The soap of which linseed oil forms a constituent part is at first white, but changes to yellow in a short time on exposure to the air. It possesses a strong odour, is unctuous, clammy, glutinous, does not dry in the air, and softens with a very small quantity of water. From what has been said we may conclude, that the soaps prepared with desiccative oils are of a very indifferent quality, that they remain always glutinous, and readily change their colour on exposure to the atmosphere. Some of the volatile oils are not less susceptible of entering into combinations with the alkalis; but as such soaps are not employed in the arts, we shall not enter into any description of these saponaceous compounds.

SOAP-STONE. See STEATITE.

SODA. Formerly called the *mineral alkali*, because under the name of *natron* it is found native in mineral seams or crusts. The impure commercial substance called *barilla* is the incinerated *salsola soda*. Kelp, the incinerated sea-weed, is a still coarser article, containing seldom above from 2 to 5 per cent. of real soda, while barilla occasionally contains 20. The crystallized carbonate of soda of commerce is procured from the decomposition of sulphate of soda, or muriate of soda. The former is effected by calcination with charcoal and chalk in a reverberatory furnace; the latter is accomplished by the addition of carbonate of potash. To procure pure soda, we must boil a solution of the pure carbonate with half its weight of quicklime, and after subsidence decant the clear ley, and evaporate in a clean iron or silver vessel, till the liquid flows quietly like oil. It must then be poured out on a polished iron plate. It concretes into a hard white cake, which is to be immediately broken in pieces, and put up, while still hot, in a phial, which must be well corked. If the carbonate of soda be somewhat impure, then, after the action of lime, and subsequent concentration of the ley, alcohol must be digested on it, which will dissolve only the caustic pure soda, and leave the heterogeneous salts. By distilling off the alcohol in a silver alembic, the alkali may then be obtained pure.

This white solid substance is, however, not absolute soda, but a hydrate, consisting of about 100 soda + 28 water; or of nearly 77 + 23, in 100. If a piece of this soda be exposed to the air, it softens and becomes pasty; but it never deliquesces into an oily-looking liquid, as potash does. The soda in fact soon becomes drier, because by absorption of carbonic acid from the air it passes into an efflorescent carbonate. Soda is distinguishable from potash by sulphuric acid, which forms a very soluble salt with the former, and a sparingly soluble one with the latter; by muriate of platina and tartaric acid, which occasion precipitates with potash salts, but not with those of soda.

The basis of soda is a peculiar metal, called *sodium*, discovered by Sir H. Davy in 1807, a few days after he discovered potassium. It may be procured in exactly the same manner as potassium, by electrical or chemical decomposition of the pure hydrate. A rather higher degree of heat, and greater voltaic power, are required to decompose soda than potash. Sodium resembles potassium in many of its characters. It is as white as silver, possesses great lustre, and is a good conductor of electricity. It enters into fusion at about 200° Fahr., and rises in vapour at a strong red heat. Its sp. gr. is, according to MM. Gay Lussac and Thenard, 0.972, at the temperature of 59° Fahr. In the cold, it exercises scarcely any action on dry air, or oxygen. But when heated strongly in oxygen or chlorine, it burns with great brilliancy. When thrown upon water, it effervesces violently, but does not inflame, swims on the surface, gradually diminishes with great agitation, and renders the water a solution of soda. It acts upon most substances in a manner similar to potassium, but with less energy. It tarnishes in the air, but more slowly; and, like potassium, it is best preserved under naphtha.

Sodium forms two distinct combinations with oxygen; one is pure soda, whose hydrate is above described; the other is the orange oxide of sodium, observed, like the preceding oxide, first by Sir H. Davy in 1807, but of which the true nature was pointed out, in 1810, by MM. Gay Lussac and Thenard.

Pure soda may be formed by burning sodium in a quantity of air, containing no more oxygen than is sufficient for its conversion into this alkali; *i. e.* the metal must be in excess: a strong degree of heat must be employed.

Pure soda is of a gray colour, it is a non-conductor of electricity, of a vitreous fracture, and requires a strong red heat for its fusion. When a little water is added to it, there is a violent action between the two bodies; the soda becomes white, crystalline in its appearance, and much more fusible and volatile. It is then the substance commonly called *pure* or *caustic soda*; but properly styled *the hydrate*.

The other oxide or peroxide of sodium may be formed by burning sodium in oxygen in excess. It is of a deep orange colour, very fusible, and a non-conductor of electricity. When acted on by water, it gives off oxygen, and the water becomes a solution of soda. It deflagrates when strongly heated with combustible bodies.

The proportions of oxygen in soda, and in the orange peroxide of sodium, are easily learned by the action of sodium on water and on oxygen. If a given weight of sodium, in a little glass tube, be thrown by means of the finger under a graduated inverted jar filled with water, the quantity of hydrogen evolved will indicate the quantity of oxygen combined with the metal to form soda; and when sodium is slowly burned in a tray of platina, (lined with dry common salt), in oxygen in great excess, from the quantity of oxygen absorbed the composition of the peroxide may be learned. From Sir H. Davy's experiments compared with those of MM. Gay Lussac and Thenard, it appears that the prime equivalent of sodium is 3·0, and that of dry soda, or protoxide of sodium, 4·0; while the orange oxide or deutoxide is 5·0. The numbers given by M. Thenard are, for the first, 100 metal + 33·995 oxygen; and for the second, 100 metal + 67·990 oxygen.

Another oxide is described containing less oxygen than soda; it is therefore a sub-oxide. When sodium is kept for some time in a small quantity of moist air, or when sodium in excess is heated with hydrate of soda, a dark grayish substance is formed, more inflammable than sodium, and which affords hydrogen by its action upon water.

Only one combination of sodium and chlorine is known. This is the important substance *common salt*. It may be formed directly by combustion, or by decomposing any compound of chlorine by sodium. Its properties are well known, and are already described under ACID (MURIATIC). It is a non-conductor of electricity, is fusible at a strong red heat, is volatile at a white heat, and crystallizes in cubes. Sodium has a much stronger attraction for chlorine than for oxygen; and soda, or its hydrate, is decomposed by chlorine, oxygen being expelled from the first, and oxygen and water from the second.

Potassium has a stronger attraction for chlorine than sodium has; and one mode of procuring sodium easily, is by heating together to redness common salt and potassium. This chloride of sodium, improperly called the muriate, consists of 4·5 chlorine + 3·0 sodium. There is no known action between sodium and hydrogen or azote.

Sodium combines readily with sulphur and with phosphorus, presenting similar phenomena to those presented by potassium. The sulphurets and phosphurets of sodium agree in their general properties with those of potassium, except that they are rather less inflammable. They form, by burning, acidulous compounds of sulphuric and phosphoric acid and soda.

Potassium and sodium combine with great facility, and form peculiar compounds, which differ in their properties, according to the proportions of the constituents. By a small quantity of sodium, potassium is rendered fluid at common temperatures, and its sp. gr. is considerably diminished. Eight parts of potassium, and one of sodium, form a compound that swims in naphtha, and that is fluid at the common temperature of the air. Three parts of sodium, and one of potassium, make a compound fluid at common temperatures. A little potassium destroys the ductility of sodium, and renders it very brittle and soft. Since the prime of potassium is to that of sodium as 5 to 3, it will require the former quantity of potassium to eliminate the latter quantity of sodium from the chloride. The attractions of potassium, for all substances that have been examined, are stronger than those of sodium.

Soda is the basis of common salt, of plate and crown-glass, and of all hard soaps. *Elements of Chemical Phil.*

SODALITE. Colour green. Massive and crystallized in rhomboidal dodecahedrons. Shining. Cleavage double. Fracture small conchoidal. Translucent. As hard as felspar. Brittle. Sp. gr. 2·378. It is infusible; becoming only dark gray before the blowpipe. Its constituents are, silica 38·5 or 36, alumina 27·48 or 32, lime 2·7 or 0, oxide of iron 1 or 0·25, soda 25·5 or 25, muriatic acid 3 or 6·75; volatile matter 2·10 or 0, loss 1·7 or 0.—*Thomson and Ekeberg*.—It was discovered in West Greenland by Sir Charles Giesecke, in a bed in mica slate.

SODIUM. See Soda.

SOIL. The soil or earth in which vegetables grow, varies considerably in its composition, or in the proportions of the different earths of which it consists; and some plants are found to thrive best in one kind of soil, others in another. Under *Analysis*, the methods of analyzing soils, so as to ascertain their composition, will be found, as given by Sir H. Davy; and we shall here subjoin the rules he has laid down for their improvement, as connected with the principles of which they consist.

In cases where a barren soil is examined with a view to its improvement, it ought in all cases, if possible, to be compared with an extremely fertile soil in the same neighbourhood, and in a similar situation: the difference given by their analyses would indicate the methods of cultivation, and thus the plan of improvement would be founded upon accurate scientific principles.

If the fertile soil contained a large quantity of sand, in proportion to the barren soil, the process of melioration would depend simply upon a supply of this substance; and the method would be equally simple with regard to soils deficient in clay or calcareous matter.

In the application of clay, sand, loam, marle, or chalk, to lands, there are no particular chemical principles to be observed; but when quicklime is used, great care must be taken, that it is not obtained from the magnesian limestone; for in this case, as has been shown by Mr. Tennant, it is exceedingly injurious to land. The magnesian limestone may be distinguished from the common limestone by its greater hardness, and by the length of time that it requires for its solution in acids; and it may be analyzed by the process for carbonate of lime and magnesia.

When the analytical comparison indicates an excess of vegetable matter as the cause of sterility, it may be destroyed by much pulverization and exposure to air, by paring and burning, or the agency of lately made quicklime. And the defect of animal and vegetable matter must be supplied by animal or vegetable manure.

The general indications of fertility and barrenness, as found by chemical experiments, must necessarily differ in different climates, and under different circumstances. The power of soils to absorb moisture, a principle essential to their productiveness, ought to be much greater in warm and dry countries than in cold and moist ones; and the quantity of fine aluminous earth they contain should be larger. Soils likewise that are situate on declivities ought to be more absorbent than those in the same climate on plains or in valleys.

The productiveness of soils must likewise be influenced by the nature of the sub-soil, or the earthy or stony strata on which they rest; and this circumstance ought to be particularly attended to, in considering their chemical nature, and the system of improvement. Thus a sandy soil may owe its fertility to the power of the sub-soil to retain water; and an absorbent clayey soil may occasionally be prevented from being barren, in a moist climate, by the influence of a sub-stratum of sand or gravel.

Those soils that are most productive of corn, contain always certain proportions of aluminous or calcareous earth in a finely divided state, and a certain quantity of vegetable or animal matter.

The quantity of calcareous earth is however very various, and in some cases exceeding small. A very fertile corn soil from Ormiston in East Lothian afforded in a hundred parts only eleven parts of mild calcareous earth; the finely divided clay amounted to forty-five phate of lime.

This soil was of a very fine texture, and contained very few stones or vegetable fibres. It is not unlikely, that its fertility was in some measure connected with the phosphate; for this substance is found in wheat, oats, and barley, and may be a part of their food.

A soil from the low lands of Somersetshire, celebrated for producing excellent crops of wheat and beans without manure, I found to consist of one-ninth of sand, chiefly siliceous, and eight-ninths of calcareous marle tinged with iron, and containing about five parts in the hundred of vegetable matter. I could not detect in it any phosphate or sulphate of lime, so that its fertility must have depended principally upon its power of attracting principles of vegetable nourishment from water and the atmosphere.

Mr. Tillet, in some experiments made on the composition of soils at Paris, found, that a soil composed of three-eighths of clay, two-eighths of river sand, and three-eighths of the parings of limestone, was very proper for wheat.

In general, bulbous roots require a soil much more sandy, and less absorbent, than the grasses. A very good potato soil, from Varsel in Cornwall, afforded seven-eighths of siliceous sand; and its absorbent power was so small, that 100 parts lost only 2 by drying at 400° Fahrenheit.

Plants and trees, the roots of which are fibrous and hard, and capable of penetrating deep into the earth, will vegetate to advantage in almost all common soils that are moderately dry, and do not contain a very great excess of vegetable matter.

The soil taken from a field at Sheffield-place in Sussex, remarkable for producing flourishing oaks, was found to consist of six parts of sand, and one part of clay and finely divided matter. And 100 parts of the entire soil submitted to analysis, produced water 3, silex 54, alumina 28, carbonate of lime 3, oxide of iron 5, decomposing vegetable matter 4, loss 3.

From the great difference of the causes that influence the productiveness of lands, it is obvious, that in the present state of science, no certain system can be devised for their improvement, independent of experiment; but there are few cases, in which the labour of analytical trials will not be amply repaid by the certainty with which they denote the best methods of melioration; and this will particularly happen, when the defect of composition is found in the proportions of the primitive earths.

In supplying animal or vegetable manure, a temporary food only is provided for plants, which is in all cases exhausted by means of a

fertility may be considered as permanently established. It becomes capable of attracting a very large portion of vegetable nourishment from the atmosphere, and of producing its crops with comparatively little labour and expense.

SOLANINE. A substance which M. Baup thinks he has extracted from potatoes. Nothing is known about it.

SOLDERS, and SOLDERING. Solders consist merely of simple or mixed metals, by which alone metallic bodies can be firmly united with each other. In this respect it is a general rule, that the solder should always be easier of fusion than the metal intended to be soldered by it; next to this, care must also be taken, that the solder be as far as is possible of the same colour with the metal that is to be soldered.

For the simple solders, each of the metals may be used, according to the nature of that which is to be soldered. For fine steel, copper, and brass work, gold and silver may be employed. In the large way, however, iron is soldered with copper, and copper and brass with tin.

The most usual solders are the compound, which are distinguished into two principal classes, viz. hard and soft solders. The hard solders are ductile, will bear hammering, and are commonly prepared of the same metal with that which is to be soldered, with the addition of some other, by which a greater degree of fusibility is obtained, though the addition is not always required to be itself easier of fusion. Under this head comes the hard solder for gold, which is prepared from gold and silver, or gold and copper, or gold, silver, and copper. The hard solder for silver is prepared from equal parts of silver and brass, but made easier of fusion by the admixture of a sixteenth part of zinc. The hard solder for brass is obtained from brass mixed with a sixth, or an eighth, or even one-half of zinc, which may also be used for the hard solder of copper. It is sold in the shops in a granulated form, under the name of spelter-solder.

The soft solders melt easily, but are partly brittle, and therefore cannot be hammered. Of this kind are the following mixtures:— Tin and lead in equal parts; of still easier fusion is that consisting of bismuth, tin, and lead, equal parts; one or two parts of bismuth of tin and lead, each one part.

In the operation of soldering, the surfaces of the metal intended to be joined must be made very clean, and applied to each other. It is usual to secure them by a ligature of iron wire, or other similar contrivance. The solder is laid upon the joint, together with sal ammoniac or borax, or common glass, according to the degree of heat intended. These additions defend the metal from oxidation. Glaziers use resin; and pitch is sometimes employed.

Tin-foil applied between the joints of fine brass work, first wetted with a strong solution of sal ammoniac, makes an excellent juncture, care being taken to avoid too much heat.

SOLIDS AND SOLIDITY. See CALORIC, and CRYSTALLIZATION.

SOLUTION. See SALT, CRYSTALLIZATION, and ATTRACTION.

SOMMITE. NEPHELINE.

SOMERVILLITE. A new mineral from Vesuvius. Primary form a right square prism. Colour dull yellow; occurring in cavities with crystallized black mica. It decrepitates at the blowpipe.

SOOT of Wood. An analysis of it is given in the Annales de Chim. et Phys. xxxi. 52, by M. Braconnot. Its constituents are,

1.	Ulmin, like that produced artificially from sawdust and potash, estimated at	30·20
2.	Animalized matter, soluble in water, insoluble in alcohol	20·00
3.	Carbonate of lime, with traces of carb. of magnesia	14·66
4.	Water	12·50
5.	Acetate of lime	5·65
6.	Sulphate of lime	5·00
7.	Acetate of potash	4·10
8.	Carbonaceous matter insoluble in alkalis	3·85
9.	Ferruginous phosphate of lime	1·50
10.	Silica	0·95
11.	Acetate of magnesia	0·53
12.	Peculiar bitter principle (asboline) about	0·50
13.	Chloride of potassium	0·36
14.	Acetate of ammonia, estimated at	0·20
15.	Acetate of iron, a trace	
		100·00

A watery infusion of soot is eminently antiseptic, according to M. Braconnot, and may be used for preserving animal matters from decomposition.

SORBATES. Compounds of sorbic, or mallic acid, with the salifiable bases. See ACID (SORBIC).

SORY. The ancient name of sulphate of iron.

SPAR (FLUOR). See FLUOR.

SPAR (PONDEROUS). See HEAVY SPAR.

SPARRY ANHYDRITE, OR CUBE-SPAR. A sub-species of prismatic gypsum. Colour white, passing into blue or red. Massive, in distinct concretions, and crystallized. The primitive figure is an oblique prism, in which the angles are 108° 8′ and 79° 56′. The secondary forms are, a rectangular four-sided prism, a broad six-sided prism, an eight-sided prism, and a broad rectangular four-sided prism, acuminated. Splendent, pearly. Cleavage threefold. Fragments cubical. Fracture conchoidal. Transparent. Refracts double. Scratches calcareous spar, but not fluor. Brittle. Sp. gr. 2·7 to 3·0. It does not exfoliate before the blowpipe, and melt like gypsum, but becomes glazed over with a white friable enamel. Its constituents are, lime 41·75, sulphuric acid 55, muriate of soda 1.—*Klaproth.* It is sometimes met with in the gypsum of Nottinghamshire. It occurs in the salt mines of Halle, &c.

SPARRY IRON. Carbonate of iron. Colour pale yellowish-gray. Massive, disseminated, and crystallized. The primitive form is a rhomboid of 107°. The following are some of the secondary forms. The primitive, perfect, or truncated; a still flatter rhomboid; the spherical lenticular form; the saddle-shaped lens, and the equiangular six-sided prism. Glistening, or splendent, or pearly. Cleavage threefold. Fracture foliated, or splintery. Translucent on the edges. Streak white or yellowish-brown. Harder than calcareous spar. Easily frangible. Sp. gr. 3·6 to 3·9. It blackens and becomes magnetic before the blowpipe, but does not melt; it effervesces with muriatic acid. Its constituents are, oxide of iron 57·5, carbonic acid 36, oxide of manganese 3·5, lime 1·25.—*Klaproth.* It occurs in veins in granite, gneiss, &c. associated with ores of lead, cobalt, silver, copper, &c. But the most extensive formations of this mineral are in limestone. It is found in small quantities in England, Scotland, and Ireland; in Saxony, Bohemia, &c.; and in large quantities in Fichtelgebirge; and at Schmalkalden in Hessia. It affords an iron well suited for conversion into steel.—*Jameson.*

SPECIFIC GRAVITY is the density of the matter of which any body is composed, compared to the density of another body, assumed as the standard. This standard is pure distilled water, at the temperature of 60° F. To determine the specific gravity of a solid, we weigh it, first in air, and then in water. In the latter case it loses, of its weight, a quantity precisely equal to the weight of its own bulk of water; and hence, by comparing this weight with its total weight, we find its specific gravity. The rule therefore is, Divide the total weight by the *loss* of weight in water, the quotient is the specific gravity. If it be a liquid or a gas, we weigh it in a glass or other vessel of known capacity; and dividing that weight by the weight of the same bulk of water, the quotient is, as before, the specific gravity. See HYDROMETER, for another modification of the same rule.

To calculate the mean specific gravity of a compound from those of its components, is a problem of perpetual recurrence in chemistry. It is only by a comparison of the result of that calculation, with the specific gravity of the compound experimentally ascertained, that we can discover whether the combination has been accompanied with expansion or condensation of volume. As several respectable experimental chemists (see ALLOY and AMMONIA) seem deficient in this part of chemical computation, I shall here insert a short abstract of a paper which I published on this subject in the 7th number of the Journal of Science.

The specific gravity of one body is to that of another, as the weight of the first, divided by its volume, is to the weight of the second, divided by its volume; and the mean specific gravity of the two is found, by dividing the sum of the weights by the sum of the volumes.

Let W, w, be the two weights; V, v, the two volumes; P, p, the two specific gravities; and M, the calculated mean specific gravity. Then

$M = \frac{W+w}{V+v}$; the formula by which I computed the second column of Table II.

$$\text{And } V + v = \frac{W}{P} + \frac{w}{p} = \frac{Wp + wP}{Pp}$$

Hence,

$$\frac{W+w}{V+v} = \frac{W+w}{\frac{Wp+wP}{Pp}} = \frac{(W+w)\,Pp}{Pw+pW} = M.$$

When the difference in density between the two substances is considerable, as it is with sulphuric acid and water, the errors produced by assuming the arithmetical mean for the true calculated mean are excessive. If we take copper and tin, however, then the arithmetical mean, $\frac{8{\cdot}89 + 7{\cdot}29}{2} = 8{\cdot}09$, differs very little from 8·01, the accurate mean density.

By a similar error, I suppose, in calculating the mean density of liquid muriatic acid in its different stages of dilution, the celebrated Kirwan has long misled the chemical world. He asserted that the mean specific gravity of the components being also the experimental mean, there is no condensation of volume, as with other acid dilutions. And the illustrious Berthollet has even assigned a cause for this supposititious fact. I find, on the contrary, that 50 of acid, sp. gr. 1·1920, with 50 of water, give out heat, and have their volume diminished in the ratio of 100 to 99·28. The experimental specific gravity is 1·0954; that, by the exact rule, is only 1·0875.

The preceding formula may be presented under a still more convenient form. P p being the specific gravities of the two components, we have $P = \frac{W}{V}$ and $p = \frac{w}{v}$;

whence $V = \frac{W}{P}$, $v = \frac{w}{p}$.

In the condition when $W = w = 1$, we have then $V = \frac{1}{P}$, $v = \frac{1}{p}$, and, consequently, therefore,

$$2\,\Delta = (P-p) \times \frac{\frac{1}{P} - \frac{1}{p}}{\frac{1}{P} + \frac{1}{p}} = \frac{(P-p)(p-P)}{P+p}$$

$$= -\frac{(P-p)^2}{P+p}.$$

This value being constantly negative proves that the true value of the specific gravity of the mixture, represented by $\frac{W+w}{V+v}$, is always smaller than the false value, $\frac{1}{2}\left(\frac{W}{V} + \frac{w}{v}\right)$.

Example of the last formula:

Gold and silver, $\frac{19{\cdot}3 + 10{\cdot}5}{2} = 14{\cdot}9 =$ false or arithmetical mean specific gravity. $\frac{(P-p)^2}{P+p} = \frac{(19{\cdot}3 - 10{\cdot}5)^2}{29{\cdot}8} = \frac{(8{\cdot}8)^2}{29{\cdot}8} = \frac{77{\cdot}44}{29{\cdot}8} = 2{\cdot}6 = 2\Delta$; and $\Delta = 1{\cdot}3$, which being subtracted from the arithmetical mean 14·9, leaves 13·6 for the true mean sp. gr. as directly obtained by the formula $\frac{(W+w)\,Pp}{Pw+pW}$.

Sulphuric Acid Table, showing the erroneous Results of the Common Method.
See ALLOY.

Acid in 100.	Arithm. mean density.	Experimental density.	Apparent volume.	Acid in 100.	Arith. mean density.	Experimental density.	Apparent volume.
100		1·8480	100	50	1·4240	1·3834	102·6
90	1·7632	1·8115	97·3	40	1·3392	1·2999	103·02
80	1·6784	1·7120	98·0	30	1·2544	1·2184	102·95
70	1·5936	1·5975	99·7	20	1·1696	1·1410	102·50
60	1·5088	1·4860	101·5	10	1·0848	1·0680	101·57

SPECULAR IRON ORE. See Ores of Iron.

SPECULUM. Mr. Edwards affirms, that different kinds of copper require different doses of tin to produce the most perfect whiteness. If the dose of tin be too small, which is the fault most easily remedied, the composition will be yellowish; if it be too great, the composition will be of a gray-blue colour, and dull appearance. He casts the speculum in sand, with the face downwards; takes it out while red-hot, and places it in hot wood ashes to cool; without which precaution it would break in cooling.

Mr. Little recommends the following proportions:—32 parts of the best bar copper, 4 parts of the brass of pin-wire, 16½ of tin, and 1¼ of arsenic. Silver he rejects, as it has an extraordinary effect of softening the metal; and he found that the compound was not susceptible of the highest polish, unless it was extremely brittle. He first melts the brass, and adds to it about an equal weight of tin. When this mixture is cold, he puts it into the copper, previously fused with black flux, adds next the remainder of the tin, and lastly the arsenic. This mixture he granulates, by pouring into cold water, as Mr. Edwards did, and fuses it a second time for casting.

SPERMACETI. See Fat.

SPHENE. Prismatic titanium ore.

SPHŒRULITE. Colours brown and gray. In imbedded roundish balls and grains. Glimmering. Fracture even, splintery. Opaque. Scratches quartz with difficulty. Brittle. Sp. gr. 2·4 to 2·5. Nearly infusible. It occurs in pearlstone and pitchstone porphyries, in the vicinity of Glasshütte near Schemnitz; and in the pitchstone of Meissen.

SPHRAGIDE. See Lemnian Earth.

SPINEL. A sub-species of octohedral corundum. Colour red. Occurs in grains, more frequently crystallized; in a perfect octohedron, which is the fundamental figure; in a tetrahedron, perfect or modified; a thick equiangular six-sided table; a very oblique four-sided table; a rhomboidal dodecahedron; a rectangular four-sided prism. Splendent and vitreous. Cleavage four-fold. Fracture flat conchoidal. Translucent to transparent. Refracts single. Scratches topaz, but is scratched by sapphire. Brittle. Sp. gr. 3·5 to 3·8. Fusible with borax. Its constituents are, alumina 82·47, magnesia 8·78, chromic acid 6·18, loss 2·57.—*Vauquelin.* It is found in the gneiss district of Acker in Sudermannland, in a primitive limestone; in the kingdom of Pegu; and in Ceylon. It is used as a precious stone. When it weighs four carats (about 16 grains), it is considered of equal value with a diamond of half the weight.—*Jameson.*

SPINELLANE. Colour plum-blue. It occurs crystallized in rhomboids of 117° 23′, and 62° 37′; and in six-sided prisms acuminated with three planes. It scratches glass. It is found on the shores of the lake of Laach, in a rock composed of glassy felspar, quartz, hornblende, &c. It is said to be a variety of Haüyne.

SPINTHERE. Colour greenish-gray. In small oblique double four-sided pyramids. It does not scratch glass. It occurs in the department of Isere in France, incrusting calcareous spar crystals. It is believed to be a variety of sphene.

SPIRIT OF MINDERERUS. A solution of acetate of ammonia, made by adding concrete carbonate of ammonia to distilled vinegar till saturation takes place.

SPIRIT OF NITRE. See Acid (Nitric).

SPIRIT (PYRO ACETIC). Some dry acetates exposed to heat in a retort yield a quantity of a light volatile spirit, to which the above name is given. When the acetate is easily decomposed by the fire, it affords much acid and little spirit; and on the contrary it yields much spirit and little acid, when a strong heat is required for its decomposition. The acetates of nickel, copper, &c. are in the first condition; those of barytes, potash, soda, strontian, lime, manganese, and zinc, are in the second. The following table of M. Chenevix, exhibits the products of the distillation of various acetates.

Table of Pyro-Acetic Spirit.

		Acetate of Silver.	Acetate of Nickel.	Acetate of Copper.	Acetate of Lead.	Peracetate of Iron.	Acetate of Zinc.	Acetate of Manganese.
Loss by the fire.		0·36	0·61	0·64	0·37	0·49		0·555
Residuum.	State of the base (*a*).	metallic.	metallic.	metallic.	metallic.	bl. oxide.	wh. oxide.	br. oxide.
	Resid. Carbon.	0·05	0·14	0·055	0·04	0·02	0·05	0·035
Liquid products.	Sp. gr.	1·0656	1·0398	1·0556	0·9407	1·011	0·8452	0·8264
	Ratio of acid.	107·309	44·731	84·863	3·045	27·236	2·258	1·28
	Pyro. spir.	0	almost 0	0·17	0·555	0·24	0·695	0·94
Gaseous products.	Carb. acid (*b*).	8	35	10	20	18	16	20
	Carb. hydro.	12	60	34	8	34	28	32
	Total gas.	20	95	44	28	52	44	52

We see, that of all the acetates, that of silver gives the most concentrated and purest acetic acid, since it contains no pyro-acetic spirit.

This spirit is limpid and colourless. Its taste is at first acrid and burning, then cooling, and in some measure urinous. Its odour approaches that of peppermint mingled with bitter almonds. Its sp. gr. is 0·7864. It burns with a flame interiorly blue, but white on the outside. It boils at 138·2 F. and does not congeal at 5° F. With water it combines in every proportion, as well as with alcohol, and most of the essential oils. It dissolves but a little of sulphur and phosphorus, but camphor in very large quantity.

Caustic potash has very little action on the pyro-acetic spirit. Sulphuric and nitric acids decompose it; but muriatic acid forms with this body a compound, which is not acid, and in which we can demonstrate the presence of the muriatic acid only by igneous decomposition. Hence we perceive that pyroacetic spirit is a peculiar substance, which resembles the ethers, alcohol, and volatile oils. To obtain it cheaply, we may employ the acetate of lead of commerce. After having distilled this salt in an earthen retort, and collected the liquid products in a globe, communicating by a tube with a flask surrounded with ice, we saturate these products with a solution of potash or soda, and then separate the spirit by means of a second distillation, taking care to use a regulated heat. As it usually carries over with it a little water, it is proper to rectify it from dry muriate of lime. *Ann. de Chimie*, tom. 69. See PYROXILIC spirit.

SPIRIT OF SAL AMMONIAC. Water of ammonia.

SPIRIT (VOLATILE) OF SAL AMMONIAC. See AMMONIA.

SPIRIT OF SALT. See ACID (MURIATIC).

SPIRIT OF WINE. Alcohol.

SPODUMENE. Prismatic triphane spar. —*Mohs*. Colour between greenish-white and mountain-gray. Massive, disseminated and in large granular concretions. Glistening, pearly. Cleavage, threefold. Fracture fine grained uneven. Translucent. As hard as felspar. Most easily frangible. Sp. gr. 3·0 to 3·1. Before the blowpipe, it first separates into small gold-yellow coloured folia; and if the heat is continued, they melt into a greenish-white coloured glass. Its constituents are, silica 64·4, alumina 24·4, lime 3, potash 5, oxide of iron 2·2.—*Vauquelin*. It was first discovered in the island of Uton in Sudermannland, where it is associated with red felspar and quartz. It has been lately found in the vicinity of Dublin, by Dr. Taylor. It contains the new alkali *lithia*, by some recent analyses.

SPONGE. A soft, light, very porous, and compressible substance, readily imbibing water, and distending thereby. It is found adhering to rocks, particularly in the Mediterranean Sea, about the islands of the Archipelago. It was formerly supposed to be a vegetable production, but is now classed among the zoophytes; and analyzed, it yields the same principles with animal substances in general.

Sponges may be bleached by soaking and squeezing them first in cold water for several days, and then in warm water. If they be now washed with cold water, slightly acidulated with sulphuric acid, starch will detect iodine

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(*a*.) Almost all the metallic residuums are pyrophoric, or susceptible of inflaming by contact of air, after complete refrigeration; which M. Chenevix ascribes to the finely divided charcoal mixed with the metallic part.

(*b*.) The quantities marked here are expressed in volumes.

in the liquid which contains hydriodate of potash. The calcareous matter contained in the sponge is best removed by a dilute muriatic acid. After washing in water, they are to be put into aqueous sulphurous acid, sp. gr. 1·034, and left for 8 days, during which time they are to be occasionally squeezed.

When well blanched, they are to be washed in much water, moistened with orange-flower water, and slowly dried in the air. *Vogel, Journ. de Pharm.* x. 499.

STALACTITES. These are found suspended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving those particles behind.

STANNANE. Protochloride of tin.

STARCH. This is a white, insipid, combustible substance, insoluble in cold water, but forming a jelly with boiling water. It exists chiefly in the white and brittle parts of vegetables, particularly in tuberose roots, and the seeds of the gramineous plants. It may be extracted by pounding these parts, and agitating them in cold water; when the parenchyma, or fibrous parts, will first subside; and these being removed, a fine white powder, diffused through the water, will gradually subside, which is the starch. Or the pounded or grated substance, as the roots of arum, potatoes, acorns, or horse chestnuts, for instance, may be put into a hair-sieve, and the starch washed through with cold water, leaving the grosser matters behind. Farinaceous seeds may be ground and treated in a similar manner. Oily seeds require to have the oil expressed from them before the farina is extracted.

If starch be subjected to distillation, it gives out water impregnated with empyreumatic acetous acid, a little red or brown oil, a great deal of carbonic acid, and carburetted hydrogen gas. Its coal is bulky, easily burned, and leaves a very small quantity of potash and phosphate of lime. If when diffused in water it be exposed to a heat of 60° F., or upward, it will ferment, and turn sour; but much more so if it be not freed from the gluten, extract, and colouring matter. Thus, in starch-making, the farina ferments and becomes sour, but the starch that does not undergo fermentation is rendered the more pure by this process. Some water already soured is mixed with the flour and water, which regulates the fermentation, and prevents the mixture from becoming putrid; and in this state it is left about ten days in summer, and fifteen in winter, before the scum is removed, and the water poured off. The starch is then washed out from the bran, and dried, first in the open air, and finally in an oven.

With boiling water starch forms a nearly transparent mucilage, emitting a peculiar smell, neither disagreeable nor very powerful. This mucilage may be dried, and will then be semitransparent, and much resembling gum; all the products of which it affords. When dissolved, it is much more easily digested and nutritious than before it has undergone this operation.

Both acids and alkalis combined with water dissolve it. It separates the oxides of several metals from their solutions, and takes oxygen from many of them. It is found naturally combined with all the immediate principles of vegetables, and may easily be united with most of them by art.

When starch is triturated with iodine, it forms combinations of various colours. When the proportion of iodine is small, these compounds are violet; when somewhat greater, blue; and when still greater, black.

We can always obtain the finest blue colour, by treating starch with an excess of iodine, dissolving the compound in liquid potash, and precipitating by a vegetable acid. The colour is manifested even at the instant of pouring water of iodine into a liquid which contains starch diffused through it. Hence iodine becomes an excellent test for detecting starch; and starch for detecting iodine. Besides these combinations, it appears that there is another of a white colour, in which the iodine exists in very small quantity. All of them possess peculiar properties, which have been described by MM. Colin and Gauthier Claubry, (*Annal. de Chimie*, xc. 92.), and M. Pelletier, (*Bulletin de Pharmacie*, vi. 289.)

Starch is not affected in the cold, by water, alcohol, or ether. But it dissolves readily when triturated with potash water. When to the solution of starch in hot water, we pour in a boiling-hot solution of sub-nitrate of lead, and leave the mixture for a considerable time at rest, a precipitate falls, which is found after washing and drying to consist of 100 starch and 38 89 protoxide of lead.--*Berzelius, Ann. de Chimie*, xcv. 82.

Starch is convertible into sugar by dilute sulphuric acid. To produce this change we must take 2000 parts of starch, diffuse them in 8000 parts of water, containing 40 parts of strong oil of vitriol; and boil the mixture for 36 hours in a basin of silver or lead, taking care to stir the materials with a wooden rod, during the first hour of ebullition. At the end of this time, the mass having become liquid, does not require to be stirred, except at intervals. In proportion as the water evaporates, it ought to be replaced. When the liquor has been sufficiently boiled, we must add to it chalk and animal charcoal, then clarify with white of egg, filter the mixture through a flock of wool, and then concentrate the liquid till it has acquired a syrupy consistence. After this, the basin must be removed from the fire, in order that, by cooling, the greater part of the sulphate of lime may fall down. The pure syrup is now to be decanted off, and evaporated to the proper dryness. The greater the quantity of acid employed, the less ebullition is required to convert the starch into the saccharine matter.—*Vogel, Ann. de Chimie*, lxxxii. 148.

The discovery of the preceding process is due to M. Kirchoff of St. Petersburgh. M. Th. de Saussure has ascertained, that no gas is given off during the operation; that the access of air is not essential to it; that the sulphuric acid is not decomposed; and that 100 parts of starch produce 110.14 of sugar.

The presence of sulphuric acid is not indispensable for obtaining sugar from starch. It may also be obtained by leaving the starch to itself, either with or without contact of air, or by mixing it with dried gluten. At the same time, indeed, several other products are formed. M. Th. de Saussure's interesting observations on this subject are published in the *Annales de Chimie et de Physique*, xi. 379. The starch, brought to the state of a pulpy mass, must be left to spontaneous decomposition. The products are, 1st, a sugar, like the sugar of grapes; 2d, Gum, like that from roasted starch; 3d, Amidine, a body whose properties are intermediate between those of starch and gum; and, 4th, an insoluble substance, like ligneous matter. In these experiments, the mass on which he operated was made by pouring 12 parts of boiling water on 1 of starch. When it was fermented by dry gluten, he obtained—

	Without coutact of air.	With contact of air.
Sugar,	47·4	49·7
Gum,	23·0	9·7
Amadine,	8·9	5·2
Amilaceous lignin,	10·3	9·2
Lignin with charcoal,	A trace	0·3
Undecomposed starch,	4·0	3·8

Potato starch differs perceptibly from that of wheat; it is more friable; is composed of ovöid grains about twice the size of the other; it requires a lower temperature to reduce it into a jelly with water; it is soluble in more dilute alkaline leys, and is less readily decomposed by spontaneous fermentation. It also contains more hygrometric water; for 100 parts of it dried at the temperature of boiling water lost 16·41 parts of water; whilst wheat starch lost by the same process only 13·66. They had both been previously exposed for some time to a dry atmosphere, at the heat of 72·5° Fahr.

Starch is composed of

	Gay Lussac and Thenard.	Berzelius.	Saussure.
Carbon,	43·55	43·481	45·39
Oxygen,	49·68	49·455	48·31
Hydrogen,	6·77	7·064	5·90
	100·00	100·000	99·60
		Azote,	0·4
			100·00

When starch is roasted at a moderate heat in an oven, it is converted into a species of gum, employed by the calico printers. Potato starch answers best for this purpose. See British Gum.

M. Caventou considers starch paste made with hot water as containing the same thing as the *amidine* of M. de Saussure.

Salop, according to him, is composed of a little gum, very little starch, and much *bassorine*.

Sago is an uniform substance, soluble in cold water, more so in hot, precipitated blue by iodine, and differing from common starch in the first property.

Tapioca seems to be identical in composition with sago.

Arrow root is nearly pure starch, agreeing in all respects with the starch of the potato, which may be converted by heat into something similar to sago and tapioca.—*Annales de Chimie et Physique*, xxxi. 337.

STAUROLITE. Grenatite, or prismatic garnet.

STAUROTIDE. Grenatite, prismatic garnet, or staurolite. Colour dark reddish-brown. Only crystallized in forms which may be reduced to a prism of 129° 30′. The following are secondary forms: a very oblique four-sided prism, truncated on the acuter lateral edges, forming an unequiangular six-sided prism; the same acutely bevelled on the extremities; and a twin crystal, formed by two perfect six-sided prisms. Splendent, resino-vitreous. Cleavage in the smaller diagonal. Fracture small grained uneven. Opaque, or translucent. Scratches quartz feebly. Brittle. Specific gravity 3.3 to 3.8. Infusible. Its constituents are, alumina 44, silica 33, lime 3.84, oxide of iron 13, oxide of manganese 1, loss 5.16.—*Vauquelin*. The geognostic relations of this mineral are nearly the same with those of precious garnet. It occurs in clay-slate near Ardonald, between Keith and Huntly, in Aberdeenshire; and in a micaceous rock at the Glenmalur lead-mines in the county of Wicklow, Ireland.

STEAM. See Caloric and Vapour.

STEARINE. See Fat.

STEATITE, or SOAPSTONE. A sub-species of rhomboidal mica. Colour grayish, or greenish-white. Massive, disseminated, imitative, and in the following supposititious figures: an equiangular six-sided prism; an acute double six-sided pyramid; and a rhomboid. The first two are on rock crystal, the last on calcareous spar. Dull. Fracture coarse splintery. Translucent on the edges. Streak shining. Writes but feebly. Soft. Very sectile. Rather difficultly frangible. Does not adhere to the tongue. Feels very greasy. Spec. grav. 2.4 to 2.6. Infusible. Its constituents are, silica 44, magnesia 44, alumina 2, iron 7.3, manganese 1.5, chrome

2. Trace of lime and muriatic acid. It occurs frequently in small contemporaneous veins that traverse serpentine in all directions; at Portsoy and Shetland; in the limestone of Icolmkill; in the serpentine of Cornwall; and in Anglesey. It is used in the manufacture of porcelain, and for taking greasy spots out of silk and woollen stuffs. It is also employed in polishing gypsum, serpentine, and marble. When pounded and slightly burned, it forms the basis of certain cosmetics. It writes readily on glass. Humboldt assures us, that the Otomacks, a savage race on the banks of the Orinoco, live for nearly three months of the year principally on a kind of potters' clay; and many other savages eat great quantities of steatite, which contains absolutely no nourishment.

STEEL. A modification of iron, concerning which our knowledge is not very precise, notwithstanding the researches of many celebrated chemists. For the following important facts, I am indebted to the proprietor of the Monkland manufactory, where bar and cast steel of superior quality are made.

The chests or troughs in which the iron bars are stratified, are 9 feet long, and composed of an open-grained siliceous freestone, unalterable by the fire. The Dannemora or Oregrounds iron is alone employed for conversion into steel at Monkland. The increase of weight is from 4 to 12 ounces per hundred weight. The average is therefore 1 in 224 parts. The first proportion constitutes mild, and the second very hard steel. Should the process be pushed much farther, the steel would then melt, and in the act of fusion would take a dose of charcoal, sufficient to bring it to the state of No. 1. cast iron. The charcoal used in stratifying with the bar iron is bruised so as to pass through a quarter-inch riddle. Whenever the interior of the troughs arrives at 70° Wedgewood, the carbon begins to be absorbed by the iron. There is no further diminution of the weight of the charcoal than what is due to this combination. What remains is employed at another charge. Great differences are found between the different kinds of bar iron imported at the same time; which occasion unexpected differences in the resulting steel. The following letter contains important information, from a gentleman possessing great experience in the manufacture of steel.

" *Monkland Steel-works,*
" *9th November*, 1820.

" Sir,—Mr. William Murray has written me, that you wished I should communicate to you the reason why bar iron should run into the state of soft cast iron, by the operation being carried too far in the blister steel furnace, and how it does not make cast steel, as cast steel is said to be formed by the fusion of the blister steel in the crucible with charcoal.

" The usual practice of making cast steel, is to fuse common steel in a crucible, *without* any charcoal being mixed. The degree of hardness required in the cast steel is regulated by selecting blister steel of the proper degree of hardness for what is wanted.

" This statement is made with the view to correct a common mistake, that to make cast steel it is necessary, and that it is the practice, to mix with the steel to be melted a quantity of charcoal.

" Pursuing this mistake, it naturally leeds to others. Dr. Thomson says, when speaking on this subject, that cast steel is more fusible than common steel, and for that reason it cannot be welded to iron. It melts before it can be heated high enough; and that the quantity of carbon is greater than in common steel; and that this seems to constitute the difference between the two substances.

" The statement of a simple fact will show that this conclusion is erroneous. Suppose a piece of blister steel, pretty hard, yet fit to stand the operation of welding to iron without any difficulty: let this steel be made into cast steel in the ordinary way. It will not then stand the process of welding. It will not melt before reaching the welding heat; but when brought to that heat, and submitted to the blows of the hammer, it will fall like a piece of sand, and the parts being once separated, they refuse to become again united. This difficulty of working the steel cannot arise from the steel containing more carbon, for the fact is, it contains less, part of it being burnt out in the operation of melting it. And if the same steel was to be melted a second time, more of the carbon would be burnt out; of course the steel would be softer, but at the same time, the difficulty of working it would be increased; or, in other words, the red-short property it had acquired in the first melting would be doubly increased in the second, although a person who has not had the experience would very naturally conclude, that as the metal kept retrograding to the state of malleable iron, in the same proportion it would acquire all the properties of the metal in that state. When taking this view of the subject, it would appear that the difference between these two kinds of steel must arise from some other cause than that pointed out by Dr. Thomson.

" When the iron has absorbed a quantity of carbon in the blister steel furnace, sufficient to constitute steel of a proper degree of hardness, and the heat after this is continued to be kept up, the steel will keep absorbing more and more carbon. The fusibility of it will continue to increase, just in the same proportion, till at last it become so fusible, that even the limited heat of a blister steel furnace brings it down; and just at the time it is passing to the fluid state, it takes so great a quantity of charcoal, as changes it from the state of steel to that of cast-iron. It appears to me, that the charcoal is combined in rich cast-iron, in the mechanical state, and not in the chemical, as in steel.

"With this you will receive a specimen from the blister steel furnace. The fracture of the bar will show you steel in the highest state of combination with carbon in which it can exist; and another part of the same fracture presents the transition from the state of steel to that of cast-iron. Should you require it, I will send you a specimen of cast-steel in the ingot, and from the same ingot, one in the hammered state. I am, &c.

"John Buttery."

A new memoir on the alloys of steel has been lately published by Messrs. Stodart and Faraday, of which the following is an abstract.

The first curious fact that occurs relates to the compound with silver, of which steel will only retain one 500th part in union; when more was used, it either evaporated, or separated as the button cooled, or was forced out in forging. The alloy was excellent, and the trifling addition of price furnishes no obstacle to its general employment.

Steel, alloyed with 100th part of platinum, though not so hard as the silver alloy, has more toughness; hence its value, where tenacity as well as hardness are required: the extra cost is more than repaid by its excellence.

The alloy with rhodium exceeds the former in its valuable qualities, but the scarcity of the metal precludes its general use. To the compounds with iridium and osmium the same remarks apply.

The action of acids on these alloys is curious, and especially in respect to that of platinum, which is acted upon by dilute sulphuric acid with infinitely greater rapidity than the unalloyed steel; indeed, an acid that scarcely touches the pure steel, dissolves the alloy with energetic effervescence. This is no doubt referable to electrical excitation; and we should apprehend that it would be fatal to the employment of this particular alloy, in any case where chemical action is likely to ensue.

The alloys of steel with gold, tin, copper, and chromium, we have not attempted in the large way. In the laboratory, steel and gold were combined in various proportions; none of the results were so promising as the alloys already named, nor did either tin or copper, as far as we could judge, at all improve steel. With titanium we failed, owing to the imperfection of crucibles. In one instance, in which the fused button gave a fine damask surface, we were disposed to attribute the appearance to the presence of titanium; but in this we were mistaken. The fact was, we had unintentionally made wootz. The button, by analysis, gave a little silex and alumina, but not an atom of titanium. Menachanite, in a particular state of preparation, was used; this might possibly contain the earths or their basis, or they may have formed a part of the crucible.

Our authors advert to the probable importance of certain triple alloys, only one of which is noticed in their paper, namely, that of steel, iridium, and osmium. "Some attempts to form other combinations of this description proved encouraging, but we were prevented at the time from bestowing on them that attention and labour they seemed so well to deserve."

The following is an important and curious paragraph of this paper:—

When pure iron is substituted for steel, the alloys so formed are much less subject to oxidation. 3 per cent. of iridium and osmium, fused with some pure iron, gave a button, which, when forged and polished, was exposed with many other pieces of iron, steel, and alloys to a moist atmosphere; it was the last of all in showing any rust. The colour of this compound was distinctly blue; it had the property of becoming harder when heated to redness, and quenched in a cold fluid. On observing this steel-like character, we suspected the presence of carbon; none, however, was found, although carefully looked for. It is not improbable that there may be other bodies, besides charcoal, capable of giving to iron the properties of steel; and though we cannot agree with M. Boussingault, *Annales de Chimie*, xvi. 1, when he would replace carbon in steel by silica, or its base, we think his experiments very interesting on this point, which is worthy of farther examination.

In conclusion, our authors observe, that to succeed in making these compounds, much attention is requisite on the part of the operators; that the purity of the metals is essential; that the perfect and complete fusion of both must be ensured; that they must be kept a considerable time in a state of thin fusion; that, after casting, the forging is with equal care to be attended to; that the metal must on no account be overheated; and that the hardening and tempering must be most carefully performed.

Upon the whole, though we consider these researches upon the alloys of steel as very interesting, we are not sanguine as to their important influence upon the improvement of the manufacture of cutlery, and suspect that a bar of the best ordinary steel, selected with precaution, and most carefully forged, wrought, and tempered, *under the immediate inspection* *of the master*, would afford cutting instruments as perfect and excellent as those composed of wootz, or of the alloys. *Phil. Trans.* 1822.

STEINHEILITE. Blue quartz of Finland.

STIBIUM. Antimony.

STILBITE, OR PYRAMIDAL ZEOLITE. See ZEOLITE.

STILPNOSIDERITE. Colour brownish-black. Massive, imitative, and in curved concretions. Splendent, resinous. Fracture conchoidal. Opaque. Streak yellowish-brown. Hard in a low degree. Brittle. Sp. gr. 3.77. With borax it gives a dark olive-green glass. Its constituents are, oxide of iron 80.5, silica 2.25, water 16, oxide of manganese a trace.—*Ullmann.* It is said to contain phosphoric acid. It occurs along with brown iron in Saxony and Bavaria. It is allied to meadow iron-ore.

STINKSTONE, OR SWINESTONE. A variety of compact lucullite, a sub-species of limestone.

STONES. See ANALYSIS, EARTHS, GEOLOGY, METEOROLITE, and MINERALOGY.

STORAX. A balsam, of which there are two varieties, a solid and liquid; consisting of resin, benzoic acid, and essential oil.

STRAHLSTEIN. Actinolite.

STRONTIA. About forty years ago, a mineral was brought to Edinburgh by a dealer in fossils, from a lead-mine at Strontian in Argyllshire, which was generally considered as a carbonate of barytes. It has since been found near Bristol, in France, in Sicily, and in Pennsylvania. Dr. Crawford first observed some differences between its solution in muriatic acid, and that obtained from the carbonate of barytes of Anglezark, and thence supposed it to be a new earth. Dr. Hope of Edinburgh had entertained the same opinion, and confirmed it by experiments in 1791. Kirwan, Klaproth, Pelletier, and Sulzer did the same. The carbonic acid may be expelled by a heat of 140° of Wedgewood, leaving the strontia behind; or by dissolving in the nitric acid, and driving this off by heat.

Pure strontia is of a grayish-white colour; a pungent, acrid taste; and when powdered in a mortar, the dust that rises irritates the lungs and nostrils. Its specific gravity approaches that of barytes. It requires rather more than 160 parts of water at 60° to dissolve it; but of boiling water much less. On cooling, it crystallizes in thin, transparent, quadrangular plates, generally parallelograms, seldom exceeding a quarter of an inch in length, and frequently adhering together. The edges are most frequently bevelled from each side. Sometimes they assume a cubic form. These crystals contain about .68 of water; are soluble in 51.4 times their weight of water at 60°, and in little more than twice their weight of boiling water. They give a blood-red colour to the flame of burning alcohol. The solution of strontia changes vegetable blues to a green. Strontia combines with sulphur either in the wet or dry way, and its sulphuret is soluble in water.

In its properties, strontia has a considerable affinity to barytes. It differs from it chiefly in being infusible, much less soluble, of a different form, weaker in its affinities, and not poisonous. Its saline compounds afford differences more marked.—*Edinburgh Trans.*

The basis of strontia is strontium, a metal first procured by Sir H. Davy in 1808, precisely in the same manner as barium, to which it is very analogous, but has less lustre. It appeared fixed, difficultly fusible, and not volatile. It became converted into strontia by exposure to air, and when thrown into water, decomposed it with great violence, producing hydrogen gas, and making the water a solution of strontia. By igniting the mineral strontianite (see HEAVY SPAR) intensely with charcoal powder, strontia is cheaply procured. Sir H. Davy, from indirect experiments, is disposed to regard it as composed of about 86 strontium + 14 oxygen, in 100 parts; and supposing it to be composed of a prime proportion of each constituent, the equivalent prime of strontium would be 6.143, and of strontia 7.143. But from the proportions of the constituents in the carbonate, the prime of strontia appears to be 6.4 or 6.5; and hence that of strontium will be 5.5.

The beautiful red fire which is now so frequently used at the theatres, is composed of the following ingredients: 40 parts dry nitrate of strontian, 13 parts of finely powdered sulphur, 5 parts of chlorate of potash (hyperoxymuriate), and 4 parts of sulphuret of antimony. The chlorate of potash and sulphuret of antimony should be powdered separately in a mortar, and then mixed together on paper; after which they may be added to the other ingredients, previously powdered and mixed. No other kind of mixture than rubbing together on paper is required. Sometimes a little realgar is added to the sulphuret of antimony, and frequently when the fire burns dim and badly, a very small quantity of very finely powdered charcoal or lampblack will make it perfect.

For the saline combinations of strontia, see the ACIDS at the beginning of the Dictionary, or Dr. Hope's Dissertation on this Earth, in the Edin. Phil. Trans. for 1790.

STRONTIANITE. See HEAVY SPAR.

STRONTITES. The same as strontia.

STRONTIUM. The metallic base of strontia.

STRYCHNIA. This alkaline substance was detected by Pelletier and Caventou in the ignatia by the following process: The bean was rasped down as small as possible. It was then exposed to the action of nitric ether in a Papin's digester. The residue thus deprived of a quantity of fatty matter was digested in alcohol as long as that reagent was capable of dissolving any thing. The alcoholic solutions were evaporated to dryness, and the residue redissolved in water. Caustic potash being dropped into the solution, a white crystalline precipitate fell, which was strychnia. It was purified by washing it in cold water, dissolving it in alcohol, and crystallizing it. Strychnia was obtained likewise from the bean of the strychnos ignatia by boiling the infusion of the bean with magnesia, in the same manner as Robiquet had obtained morphia from the infusion of opium.

Strychnia has been since extracted from the Upas poison (Upas tiente and Upas anthiar) by the same chemists. It constitutes the poisonous principle of these plants.—*Ann. de Chim. et de Phys.* xxvi. 44.

The properties of strychnia, when in a state of purity, are as follows:

It is crystallized in very small four-sided prisms, terminated by four-sided low pyramids. It has a white colour, its taste is intolerably bitter, leaving a metallic impression in the mouth. It is destitute of smell. It is not altered by exposure to the air. It is neither fusible nor volatile, except at temperatures at which it undergoes decomposition. It is charred at the temperature at which oil enters into ebullition (about 580°). When strongly heated, it swells up, blackens, gives out empyreumatic oil, a little water and acetic acid; carbonic acid and carburetted hydrogen gases are disengaged, and a bulky charcoal remains behind. When heated with peroxide of copper, it gives out only carbonic acid gas and water. It is very little soluble in cold water, 100,000 parts of that liquid dissolving only 15 parts of strychnia; but it dissolves in 2,500 times its weight of boiling water. A cold solution of strychnia in water may be diluted with 100 times its volume of that liquid without losing its bitter taste.

When strychnia is introduced into the stomach, it acts with prodigious energy. A locked jaw is induced in a very short time, and the animal is speedily destroyed. Half a grain of strychnia blown into the throat of a rabbit proved fatal in five minutes, and brought on locked jaw in two minutes.

Sulphate of strychnia is a salt which crystallizes in transparent cubes, soluble in less than ten times its weight of cold water. Its taste is intensely bitter, and the strychnia is precipitated from it by all the soluble salifiable bases. It is not altered by exposure to again, with a loss of three per cent. of its weight. At a still higher temperature it is decomposed and charred. Its constituents are,

Sulphuric acid,	9·5	5·00
Strychnia,	90·5	47·63
	100·0	

Muriate of strychnia crystallizes in very small needles, which are grouped together, and before the microscope exhibit the form of quadrangular prisms. When exposed to the air it becomes opaque. It is more soluble in water than the sulphate, has a similar taste, and acts with the same violence upon the animal economy as all the other salts of strychnia. When heated to the temperature at which the base is decomposed, it allows the muriatic acid to escape.

Phosphate of strychnia crystallizes in four-sided prisms. It can only be obtained neutral by double decomposition.

Nitrate of strychnia can be obtained only by dissolving strychnia in nitric acid, diluted with a great deal of water. The saturated solution, when cautiously evaporated, yields crystals of neutral nitrate in pearly needles. This salt is much more soluble in hot than in cold water. Its taste is exceedingly bitter, and it acts with more violence upon the animal economy than pure strychnia. It seems capable of uniting with an excess of acid. When heated it becomes yellow, and undergoes decomposition. It is slightly soluble in alcohol, but is insoluble in ether.

When concentrated nitric acid is poured upon strychnia, it immediately strikes an amaranthine colour, followed by a shade similar to that of blood. To this colour succeeds a tint of yellow, which passes afterwards into green. By this action, the strychnia seems to be altered in its properties, and to be converted into a substance still capable of uniting with acids.

Carbonate of strychnia is obtained in the form of white flocks, little soluble in water, but soluble in carbonic acid.

Acetic, oxalic, and tartaric acids, form with strychnia neutral salts, which are very soluble in water, and more or less capable of crystallizing. They crystallize best when they contain an excess of acid. The neutral acetate is very soluble, and crystallizes with difficulty.

Hydrocyanic acid dissolves strychnia, and forms with it a crystallizable salt.

Strychnia combines neither with sulphur nor carbon. When boiled with iodine, a solution takes place, and iodate and hydriodate of strychnia are formed. Chlorine acts upon it precisely in the same way.

Strychnia, when dissolved in alcohol, has the property of precipitating the greater number of metallic oxides from their acid solutions. It is precipitated by the alkalis and alkaline earths: but the effect of the earths proper has not been tried. See *Ann. de Chim. et de Phys.* x. 142.

A new process for extracting strychnia from nux vomica has been lately published by M. Henry, in the Journal de Pharmacie for September 1822. The details are inserted in the Journal of Science and the Arts, xiv. 443.

Another process is given in the *Glor. de Fisica* by M. Ferrari, which is translated into the *Journal of Science*, xvii. 170. M. Ferrari further remarks that the solutions of the salts of strychnia, as of the sulphate, nitrate, muriate, and acetate slightly acid, when exposed to a heat of 212°, become volatile, and the salt evaporates.

STUCCO. Gypsum.

SUBER. Cork. See CERIN, and ACID (SUBERIC).

SUBLIMATION is a process by which volatile substances are raised by heat, and again condensed in the solid form.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all that has been said on the article DISTILLATION is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases: for instance, to combine volatile matters together, as in the operation of the sublimates of mercury; or to collect some volatile substances, as sulphur, the acid of borax, and all the preparations called flowers.

The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels, and the method of managing the fire, vary according to the nature of the matters which are to be sublimed, and according to the form which is to be given to the sublimate.

The beauty of some sublimates consists in their being composed of very fine, light parts, such as almost all those called flowers; as flowers of sulphur, of benzoin, and others of this kind. When the matters to be sublimed are at the same time volatile, a high cucurbit, to which is adapted a capital, and even several capitals placed one upon another, are employed. The sublimation is performed in a sand bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed, and the capitals are to be guarded as much as possible from heat. The height of the cucurbit and of the capital seems well contrived to accomplish this intention.

When along with the dry matter which is to be collected in these sublimations, a certain quantity of some liquor is raised, as happens in the sublimation of acid of borax, and in the rectification of volatile concrete alkali, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordinary capital of the alembic, furnished with a beak and a receiver.

Some sublimates are required to be in masses as solid and compact as their natures allow. Of this number are camphor, muriate of ammonia, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasses, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part, and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art, therefore, of conducting these sublimations consists in applying such a degree of heat, or in so disposing the sand (that is, making it cover more or less the matrass), that the heat in the upper part of the matrass shall be sufficient to make the sublimate adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time this heat must not be so great as to force the sublimate through the neck of the matrass, and dissipate it. These conditions are not easily to be attained, especially in great works.

Many substances may be reduced into flowers, and sublimed, which require for this purpose a very great heat, with the access of free air and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most soots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air; and the flowers are collected in the chimney of the furnace in which the operation is performed. The tutty, calamine, or pompholix, collected in the upper part of furnaces in which ores are smelted, are sublimates of this kind.

SUBLIMATE (CORROSIVE). Bichloride of mercury.

SUBSALT. A salt having an excess of base beyond what is requisite for saturating the acid, as *supersalt* is one with an excess of the acid. The sulphate of potash is the neutral compound of sulphuric acid and potash; subsulphate of potash, a compound of the same ingredients, in which there is an excess of base; supersulphate of potash, a compound of the same acid and the same base, in which acid with the salifiable bases.

SUCCINIC ACID. See ACID (SUCCINIC).

SUGAR is a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, skirret, parsnips, and dried grapes. The process of this chemist consisted in digesting these roots, rasped, or finely divided, in alcohol. This fluid dissolves the sugar; and leaves the extractive matter untouched, which falls to the bottom.

In Canada, the inhabitants extract sugar from the maple. At the commencement of spring, they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage of the returning sap. Two hundred pounds of this juice afford, by evaporation, fifteen of a brownish sugar. The quantity prepared annually amounts to fifteen thousand weight.

Dr. Rush, in the Transactions of the American Philosophical Society, vol. iii. has given an account, at length, of the sugar maple tree, of which the following is a short abstract:—

The *acer saccharinum* of Linnæus, or sugar maple tree, grows in great quantities in the western counties of all the middle States of the American Union. It is as tall as the oak, and from two to three feet in diameter; puts forth a white blossom in the spring, before any appearance of leaves; its small branches afford sustenance for cattle, and its ashes afford a large quantity of excellent potash. Twenty years are required for it to attain its full growth. Tapping does not injure it; but, on the contrary, it affords more syrup, and of a better quality, the oftener it is tapped. A single tree has not only survived, but flourished, after tapping, for forty years. Five or six pounds of sugar are usually afforded by the sap of one tree; though there are instances of the quantity exceeding twenty pounds. The sugar is separated from the sap either by freezing, by spontaneous evaporation, or by boiling. The latter method is the most used. Dr. Rush describes the process; which is simple, and practised without any difficulty by the farmers.

From frequent trials of this sugar, it does not appear to be in any respect inferior to that of the West Indies. It is prepared at a time of the year when neither insect, nor the pollen of plants, exist to vitiate it, as is the case with common sugar. From calculations grounded on facts, it is ascertained, that America is now capable of producing a surplus of one-eighth more than its own consumplar.

The Indians likewise extract sugar from the pith of the bamboo.

The beet has lately been much cultivated in Germany, for the purpose of extracting sugar from its root. For this the roots are taken up in autumn, washed clean, wiped, sliced lengthwise, strung on threads, and hung up to dry. From these the sugar is extracted by maceration in a small quantity of water; drawing off this upon fresh roots, and adding fresh water to the first roots, which is again to be employed the same way, so as to get out all their sugar, and saturate the water as much as possible with it. This water is to be strained and boiled down for the sugar.

Some merely express the juice from the fresh roots, and boil this down; others boil the roots; but the sugar extracted in either of these ways is not equal in quality to the first.

Professor Lampadius obtained from 110lbs. of the roots, 4lbs. of well grained white powder sugar; and the residuums afforded 7 pints of a spirit resembling rum. Achard says, that about a ton of roots produced him 100lbs. of raw sugar, which gave 55lbs. of refined sugar, and 25lbs. of treacle.

But the sugar which is so universally used is afforded by the sugar cane (*arundo saccharifera*) which is raised in our colonies. When this plant is ripe, it is cut down, and crushed by passing it between iron cylinders placed perpendicularly and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. The juice is called in the French sugar colonies *vesou*; and the cane, after having undergone this pressure, is called *begasse*. The juice is more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood ashes and lime. It is subjected to the same operation in three several boilers, care being taken to remove the scum as it rises. In this state it is called *syrup*; and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the *cooler*. In this vessel it is agitated with wooden stirrers, which break the crust as it forms on the surface. It is afterwards poured into casks, to accelerate its cooling; and while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their through these canes into the cistern beneath; and leaves the sugar in the state called *coarse sugar*, or *muscovado*. This sugar is yellow and fat, and is purified in the islands in the following manner: The syrup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead, which being well pressed down, the whole is covered with clay, moistened with water. This water filters through the mass, carrying the syrup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called *fine syrup*. Care is taken to moisten and keep the clay to a proper degree of softness, as it becomes dry. The sugar loaves are afterward taken out, and dried in a stove for eight or ten days; after which they are pulverized, packed, and exported to Europe, where they are still farther purified.

The operation of the French sugar refiners consists in dissolving the cassonade, or clayed sugar, in lime water. Bullocks' blood is added, to promote the clarifying: and, when the liquor begins to boil, the heat is diminished, and the scum carefully taken off. It is in the next place concentrated by a brisk heat; and, as it boils up, a small quantity of butter is thrown in, to moderate its agitation. When the boiling is sufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the syrup together with the grain sugar already formed. When the whole is cold, the moulds are opened, and the loaves are covered with moistened clay, which is renewed from time to time till the sugar is well cleansed from its syrup. The loaves being then taken out of the moulds, are carried to a stove, where they are gradually heated to 145° F. They remain in this stove eight days, after which they are wrapped in blue paper for sale.

The several syrups treated by the same methods afford sugars of inferior qualities; and the last portion, which no longer affords any crystals, is sold by the name of *melasses*. The Spaniards use this melasses in the preparation of sweetmeats.

A solution of sugar, much less concentrated than that we have just been speaking of, lets fall by repose crystals, which affect the form of tetrahedral prisms, terminated by dihedral summits, and known by the name of *sugar-candy*.

from Chaptal. The following is take
Edwards' History of the West Indies,
thority of which is indubitable.

Such planters as are not fortunatel
nished with the means of grinding their
by water are at this season frequentl
peded by the failure or insufficiency o
mills; for though a sugar mill is a very
contrivance, yet great force is requisite to
it vanquish the resistance which it neces
meets with. It principally consists of
upright iron rollers or cylinders, from
to forty inches in length, and from twe
twenty-five inches in diameter; and th
dle one, to which the moving power is ap
turns the other two by means of cogs.
canes, which are previously cut short an
into bundles, are twice compressed be
these rollers; for after they have passed th
the first and second rollers, they are
round the middle one by a piece of frame
of a circular form, which is called in J
the dumb-returner, and forced back th
the second and third. By this operatio
are squeezed completely dry, and som
even reduced to powder. The cane-j
received in a leaden bed, and thence co
into a vessel called the receiver. The
or macerated rind of the cane, which is
cane-trash, serves for fuel to boil the liq

The juice from the mill usually c
eight parts of pure water, one part of
and one part made up of gross oil and
lage, with a portion of essential oil.
proportions are taken at a medium; fo
juice has been so rich as to make a ho
or sixteen hundred weight of sugar fro
teen hundred gallons, and some is so
as to require more than double that qu
The richer the juice is, the less it al
with redundant oil and gum; so th
little knowledge of the contents of an
quantity can be obtained by the mos
analysis of any one quantity of juice.

The following matters are likewise
contained in cane-juice. Some of th
tops, which serve to tie the canes in b
are often ground in, and yield a raw aci
exceedingly disposed to ferment and ren
whole liquor sour. Beside these the
in some pieces of the ligneous part of th
some dirt, and lastly, a substance of so
portance, which may be called the
This substance is a thin black coat of
that surrounds the cane between the
beginning at each joint, and graduall
ing thinner the farther from the joint u
till the upper part between the joints
entirely free from it, and assumes its
yellow colour. It is a fine black powd
mixes with the clammy exudations fr
cane; and as the fairness of the suga

symptom of its goodness, a small quantity of this crust must very much prejudice the commodity.

The sugar is obtained by the following process:—The juice or liquor runs from the receiver to the boiling-house, along a wooden gutter lined with lead. In the boiling-house, it is received into one of the copper pans or caldrons called clarifiers. Of these there are generally three; and their dimensions are determined by the power of supplying them with liquor. There are water mills that will grind with great facility sufficient for thirty hogsheads of sugar in a week. Methods of quick boiling cannot be dispensed with on plantations thus fortunately provided; for otherwise the cane liquor would unavoidably become tainted before it could be exposed to the fire. The purest cane-juice will not remain twenty minutes in the receiver without fermenting. Hence, clarifiers are sometimes seen of one thousand gallons each. But on plantations that, during crop time, make from fifteen to twenty hogsheads of sugar a-week, three clarifiers of three or four hundred gallons each are sufficient. The liquor, when clarified, may be drawn off at once, with pans of this size, and there is leisure to cleanse the vessels every time they are used. Each clarifier is furnished either with a siphon or cock for drawing off the liquor. It has a flat bottom, and is hung to a separate fire, each chimney having an iron slider, which, when shut, causes the fire to be extinguished through want of air[*].

As soon as the stream from the receiver has filled the clarifier with fresh liquor, and the fire is lighted, the temper, which is generally Bristol white-lime in powder, is stirred into it. This is done in order to neutralize the superabundant acid, and to get rid of which is the greatest difficulty in sugar making. Alkali, or lime, generally effects this; and at the same time part of it is said to become the basis of the sugar. Mr. Edwards affirms, that it affects both the smell and taste of the sugar. It falls to the bottom of the pans in a black insoluble matter, which scorches the bottom of the vessels, and cannot without difficulty be detached from them. But, in order that less of the lime may be precipitated to the bottom, little more than half a pint of Bristol lime should be allowed to every hundred gallons of liquor, and Mr. Bousie's method of dissolving it in boiling water previous to mixing it with the cane-juice should be adopted[†].

As the force of the fire increases, and the liquor grows hot, a scum is thrown up, which is formed of the gummy matter of the cane, with some of the oil, and such impurities as the mucilage is able to entangle. The heat is now suffered to increase gradually till it nearly rises to the heat of boiling water. The liquor, however, must by no means be suffered to boil. When the scum begins to rise into blisters, which break into white froth, and generally appear in about forty minutes, it is known to be sufficiently heated. Then the damper is applied, and the fire extinguished; and, if circumstances will admit, the liquor after this is suffered to remain a full hour undisturbed. In the next place, it is carefully drawn off, either by a siphon, which draws up the clear fluid through the scum, or by means of a cock at the bottom. In either case, the scum sinks down without breaking as the liquor flows; for its tenacity prevents any admixture. The liquor is received into a gutter or channel, which conveys it to the evaporating boiler, commonly called the grand copper; and if produced at first from good and untainted canes, it will then appear almost transparent.

In the grand or evaporating copper, which should be sufficiently large to receive the net contents of one of the clarifiers, the liquor is suffered to boil, and the scum as it rises is continually taken off by large scummers, till the liquor becomes finer and somewhat thicker. This operation is continued, till the subject is so reduced in quantity, that it may be contained in the next or second copper, into which it is then ladled. The liquor is now almost of the colour of Madeira wine. In the second copper the boiling and scumming are continued; and if the subject be not so clean as is expected, lime water is thrown into it. This addition not only serves to give more temper, but likewise to dilute the liquor, which sometimes thickens too fast to permit the feculencies to rise in the scum. When the froth in boiling arises in large bubbles, and is not much discoloured, the liquor is said to have a favourable appearance in the second copper. When, in consequence of such scumming and evaporation, the liquor is again so reduced that it may be contained in the third copper, it is ladled into it, and so on to the last copper, which is called the teache. This arrangement supposes four boilers or coppers, besides the three clarifiers.

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[*] The clarifiers are generally placed in the middle or at one end of the boiling-house. When they are placed at one end, the boiler called the *teache* is placed at the other, and three boilers are usually ranged between them. The teache commonly holds from 70 to 100 gallons, and the boilers between the clarifiers and teache diminish in size from the first to the last. But when the clarifiers are in the middle, there is generally a set of three boilers on each side, which in effect form a double boiling-house. This arrangement is very necessary on large estates.

[†] Mr. Bousie, to whom, for his improvements in the art of sugar-boiling, the Assembly of Jamaica gave 1000*l*., in a paper which he distributed among the members, recommends the use of vegetable alkali, or ashes of wood, such as pimento tree, dumb cane, fern tree, cashew, or logwood, as affording a better temper than quicklime. Afterward, however, he was convinced, that sugar formed on the basis of fixed alkaline salts never stands the sea, unless some earth is united to the salts. Such earth as approaches nearest to the basis of alum, Mr. Edwards thinks, would be most proper; and it deserves to be inquired, how far a proper mixture of vegetable alkaline salts and lime might prove a better temper than either lime or alkaline salts alone. In some parts of Jamaica, where the cane-liquor was exceedingly rich, Mr. Bousie made very good sugar without a particle of temper.

In the teache the subject undergoes another evaporation, till it is supposed boiled enough to be removed from the fire. This operation is usually called striking, i. e. ladling the liquor, which is now exceeding thick, into the cooler.

The cooler, of which there are generally six, is a shallow wooden vessel, about eleven inches deep, seven feet in length, and from five to six feet wide. A cooler of this size holds a hogshead of sugar. Here the sugar grains, i. e. as it cools it runs into a coarse irregular mass of imperfect crystals, separating itself from the melasses. From the cooler it is taken to the curing-house, where the melasses drains from it*.

But here it may be proper to notice the rule for knowing when the subject is fit to be ladled from the teache to the cooler. Many of the negro boilers, from long habit, guess accurately by the eye alone, judging by the appearance of the grain on the back of the ladle; but the practice generally adopted, is to judge by what is called the touch, i. e. taking up with the thumb a small portion of the hot liquor from the ladle, and, as the heat diminishes, drawing with the forefinger the liquid into a thread. This thread will suddenly break and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. A thread of a quarter of an inch long generally determines the proper boiling height for strong muscovado sugar †.

The curing-house is a large airy building, provided with a capacious melasses cistern, the sides of which are sloped and lined with terras, or boards. A frame of massy joist-work without boarding is placed over this cistern; and empty hogsheads without headings are ranged on the joints of this frame. Eight or ten holes are bored in the bottoms of these hogsheads, and through each of the holes the stalk of a plaintain leaf is thrust six or eight inches below the joists, and long enough to stand upright above the top of the hogshead. Into these hogsheads the mass from the cooler is put, which is called potting; and the melasses drains through the spongy stalk, and drops into the cistern, whence it is occasionally taken for distillation. In the space of three weeks, the sugar becomes tolerably dry and fair. It is then said to be cured, and the process is finished.

Sugar thus obtained is called muscovado, and is the raw material whence the British sugar-bakers chiefly make their loaf or refined lump. There is another sort, which was formerly much used in Great Britain for domestic purposes, and was generally known by the name of Lisbon sugar. In the West Indies it is called clayed sugar; and the process of making it is as follows:—

A quantity of sugar from the cooler is put into conical pots or pans, which the French call *formes*, with the points downward, having a hole about half an inch in diameter at the bottom for the melasses to drain through, but which at first is closed with a plug. As soon as the sugar in these pots is cool, and becomes a fixed body, which is known by the middle of the top falling in, the plug is taken out, and the pot placed over a large jar, intended to receive the syrup or melasses that drain from it. In this state it is left as long as the melasses continues to drop, when a stratum of clay is spread on the sugar, and moistened with water. This imperceptibly oozing through the pores of the clay, dilutes the melasses, in consequence of which more of it comes away than from sugar cured in the hogshead, and the sugar of course becomes so much whiter and purer. According to Sloane, the process was first discovered in Brasil, by accident: "A hen," says he, "having her feet dirty, going over a pot of sugar, it was found under her feet to be whiter than elsewhere." The reason assigned why this process is not universally adopted in the British sugar islands is this, that the water which dilutes and carries away the melasses, dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. It is probable, however, that the French planters are of a different opinion; for upwards of four hundred of the plantations of St. Domingo have the necessary apparatus for claying, and actually carry on the system.

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* It is necessary to observe in this place, that, in order to obtain a large-grained sugar, it must be suffered to cool slowly and gradually. If the coolers be too shallow, the grain is injured in a surprising manner.

† The vessel called the teache probably derived its name from this practice of trying by the touch (tactio). Some years ago, John Proculus Baker, Esq. barrister at law, recommended to the public a method more scientific and certain, in a treatise which he published in 1775, entitled, An Essay on the Art of making Muscovado Sugar. It is as follows: "Provide a small thin pane of clear crown glass, set in a frame, which I would call a tryer; on this drop two or three drops of the subject, one on the other, and carry your tryer out of the boiling-house into the air. Observe your subject, and more particularly whether it grain freely, and whether a small edge of melasses separate at the bottom. I am well satisfied, that a little experience will enable you to judge what appearance the whole skip will put on when cold, by this specimen, which is also cold. This method is used by chemists, to try evaporated solutions of all other salts: it may seem therefore somewhat strange it has not been long adopted in the boiling-house."

Sugar is very soluble in water, and is a good medium for uniting that fluid with oily matters. It is much used for domestic purposes, and appears on the whole to be a valuable and wholesome article of food, the uses of which are most probably restricted by its high price. This price may in a certain degree arise from the nature of the article, and its original cost; but is no doubt in a great measure owing to the inhuman and wasteful culture by slaves, and the absurd principles of European colonization, duties, drawbacks, and bounties, which have the effect to create unnatural monopolies, and to prevent commerce from finding its level. This is eminently the case with regard to our West India islands, and their produce.

It appears that sugar has the property of rendering some of the earths soluble in water. This property was accidentally discovered by Mr. William Ramsay, of Glasgow.

Being employed in making experiments on sugar, and happening to put some quicklime into a cold solution of it, he noticed, that it had acquired an uncommon caustic taste.

Hence he concluded, that sugar possesses the property of dissolving a certain proportion of lime; and in order to ascertain its capacity in this respect, experiments were made upon this earth, together with strontites, magnesia, and barytes.

Sugar, dissolved in water at the temperature of 50°, is capable of dissolving one-half of its weight of lime.

The solution of lime in sugar is of a beautiful white-wine colour, and has the smell of fresh-slacked quicklime.

It is precipitated from the solution, by the carbonic, citric, tartaric, sulphuric, and oxalic acids; and it is decomposed, by double affinity, by caustic and carbonated potash and soda, the citrate, tartrate, and oxalate of potash, &c.

An equal weight of strontia, with the sugar employed, is capable of being dissolved at the temperature of 212°, and of being retained in solution by the sugar at 50° of Fahrenheit. On exposing the crystals, which had fallen down during the cooling of the liquid, to the air of the atmosphere, they attracted carbonic acid, and effloresced.

The solution of strontia in sugar is of a fine white-wine colour, and, like that of lime, has a peculiar caustic smell. This earth is precipitated by caustic and carbonated potash and soda; also by the carbonic, citric, tartaric, sulphuric, and oxalic acids; and it is decomposed, by compound affinity, by the carbonates of potash and soda; also by the citrate, tartrate, and oxalate of potash.

The solution of magnesia in syrup, like those of lime and strontia, was of a pure white colour, and had no sensible variation in smell or taste from the common solution of sugar, farther than that the sweet seemed much improved, and was softer and more agreeable to the palate, as if it were entirely freed from the earthy taste which unrefined sugar frequently has. On its remaining at rest for some months in a bottle well corked, the magnesia appears to be entirely separated.

Very little alumina is dissolved by a solution of sugar, when fresh precipitated earth is presented to it, either in the cold or hot state.

The union of sugar with the alkalis has been long known; but this is rendered more strikingly evident, by carbonated potash or soda, for instance, decomposing the solutions of lime and strontia in sugar, by double affinity.

The power possessed by tartaric acid of preventing the precipitation of iron and some other metals from their muriatic solution, is well known from the observations of M. Rose and others. A similar effect is produced by sugar, according to M. Peschier, if the mixture be boiled, but not otherwise.—*Ann. de Chim. et Phys.* xxxi. 197.

In making solutions of unrefined sugar for culinary purposes, a gray-coloured substance is found frequently precipitated. It is probable, that this proceeds from a superabundance of lime, which has been used in clarifying the juice of the sugar-cane at the plantations abroad. Sugar with this imperfection is known among the refiners of this article by the name of *weak*. And it is justly termed so, the precipitated matter being nothing but lime which has attracted carbonic acid from the sugar, (of which there is a great probability), or from the air of the atmosphere. A bottle in which I had kept a solution of lime in sugar for at least four years, closely corked, was entirely incrusted with a yellowish-coloured matter, which on examination was found to be entirely carbonate of lime.

In the ordinary refining of raw sugars, from twenty to thirty-five per cent. of melasses are separated, of which a considerable part, probably two-thirds, are formed by the high heat used in the concentration of the syrup. Various plans have been contrived to diminish this production of melasses. One of these consisted in surrounding the sugar boiler with oil or steam at a high temperature, instead of exposing it to a naked fire. In a second, the boiler is covered at top, and by means of an air-pump the atmospheric pressure is removed, so as to favour ebullition, and rapid evaporation, at moderate heats.

The celebrated chemist, Mr. Howard, took out a patent for this plan, which is undoubtedly the most scientific and productive of any; but requires superior skill and very minute attention in the manufacturer. No blood is used for clarification. This is accomplished by a system of most ingenious canvass filters, aided by the intermixture with the syrup of a small quantity of pasty gypsum and alumina, made by saturating a solution of alum with quicklime. In the final purification, the base of the inverted sugar-cone is covered with a stratum of very pure saturated syrup, instead of moist pipe-clay.

The third method is founded on the property which animal charcoal (bone-black) possesses, of destroying vegetable colouring matter. Perhaps the combination of the last two modes promises the best results.

A fourth process for refining sugar is that of Mr. Daniel Wilson, for which a patent was granted. The specification is in the 34th vol. of the Repertory, p. 134.

The pan is to be charged with strong lime-water, the sugar added, and the fire set in the usual manner. For every hundred weight of sugar used, a solution is to be made of four ounces of sulphate of zinc, in as small a quantity of water as will dissolve it. When the sugar in the pan is melted, the solution of sulphate of zinc is added, and the whole well stirred. The oxide of zinc combines with the extractive matter, tannin and gallic acid, and renders them insoluble, while the sulphuric acid, in combination with the lime, becomes also insoluble. When raw sugar contains much acid, and a strong grain is required, take one ounce of lime in powder for every four ounces of sulphate of zinc, and as much water as will form a milk of lime, which is added to the solution of sugar in the pan, about five minutes after the solution of sulphate of zinc has been added. This purification of sugar by separating impurities chemically combined with it, is employed with much advantage in conjunction with the patent filtering apparatus invented by Mr. John Sutherland. The solution of sugar brought to the boiling point is run through the filter, and afterwards boiled to a proof. Mr. Wilson boils the syrup in a pan, having a coil of tinned copper or pure tin tubes placed along its bottom and sides, through which a constant stream of strongly heated oil, or other fatty matter, is made to pass. The oxide of zinc precipitated previously by adding a solution of the salt to lime water, is also recommended, as well as the oxide of tin.

Mr. Kirchoff, an ingenious Russian chemist, accidentally discovered, that starch is convertible into sugar, by being boiled for some time with a very dilute sulphuric acid. Saussure showed, that 100 parts of starch yield 110 of sugar. He concluded, that this sugar is merely a compound of water and starch. According to his analysis, starch consists of

Oxygen,	56·87
Carbon,	37·29
Hydrogen,	6·84
	100·00

Sugar of grapes, according to the same chemist, is composed of,

Oxygen,	56·51
Carbon,	36·71
Hydrogen,	6·78
	100·00

Common sugar has been analyzed by many eminent chemists. The following is a general view of the results:—

	G. Lussac and Thenard.	Berzelius, Mean of 3.	Prout.
Oxygen,	50·63	49·856	53·35
Carbon,	42·47	43·265	39·99
Hydrogen,	6·90	6·879	6·66
	100·00	100·000	100·00

By my ultimate analysis of sugar, its constituents are,

Carbon,	43·38	5 atoms	45·4
Hydrogen,	6·29	4	6·1
Oxygen,	50·33	4	48·5
	100·00		100·0

Phil. Trans. 1822.

For a view of the proportions of the constituents referred to equivalent primes or volumes, see FERMENTATION, *column* 4. It may be observed that Dr. Prout's experimental results agree with M. Gay Lussac's theory, of sugar being a compound of 40 parts of carbon + 60 of water, or its elements. By Berzelius's analysis, starch consists of,

Oxygen	49·5
Carbon,	43·5
Hydrogen,	7·0
	100·0

The abstraction of a little hydrogen and carbon would convert it into sugar. But no carbonic acid or other gas is extricated during the conversion, according to Vogel's experiments. I find that potatoes digested with dilute sulphuric acid, yield sugar cheaply and abundantly. The acid is afterwards removed by chalk; and the strained liquor left to repose, after due evaporation, affords crystals of sugar. From starch sugar, good beer has been made. I would recommend potatoes for this purpose. They are washed, grated down, and treated with the dilute acid for a day or two at a temperature of 212°.

M. Braconnot has recently extended our views concerning the artificial production of sugar and gum. Sulphuric acid (sp. gr. 1·827) mixed with well dried elm dust, became very hot, and on being diluted with water, and neutralized with chalk, afforded a liquor which became gummy on evaporation. Shreds of linen triturated in a glass mortar, with sulphuric acid, yield a similar gum. Nitric acid has a similar power. If the gummy matter from linen be boiled for some time with dilute sulphuric acid, we obtain a crystallizable sugar, and an acid, which M. Braconnot calls the vegeto-sulphuric acid. The conversion of wood also into sugar will no doubt appear remarkable; and when persons not familiarized with chemical speculations are told, that a pound weight of rags can be converted into more than a pound weight of sugar, they may regard the statement as a piece of pleasantry, though nothing, says M. Braconnot, can be more real.

Silk is also convertible into gum by sulphuric acid. Twelve grammes of glue, reduced to powder, were digested with a double weight of concentrated sulphuric acid without artificial heat. In twenty hours the liquid was not more coloured than if mere water had been employed. A decilitre of water was then added, and the whole was boiled for five hours, with renewal of the water, from time to time, as it wasted. It was next diluted, saturated with chalk, filtered, and evaporated to a syrupy consistence, and left in repose for a month. In this period a number of granular crystals had separated, which adhered pretty strongly to the bottom of the vessel, and had a very decided saccharine taste. This sugar crystallizes much more easily than cane sugar. The crystals are gritty under the teeth, like sugar-candy; and in the form of flattened prisms or tabular groupes. Its taste is nearly as saccharine as grape sugar; its solubility in water scarcely exceeds that of sugar of milk. Boiling alcohol, even when diluted, has no action on this sugar. By distillation it yields ammonia, indicating the presence of azote. This sugar combines intimately with nitric acid, without sensibly decomposing it, even with the assistance of heat, and there results a peculiar crystallized acid, to which the name nitro-saccharine has been given. *Annales de Chimie*, xii. or *Tilloch's Magazine*, vol. 55 *and* 56.

The varieties of sugar are; cane sugar, maple sugar, liquid sugar of fruits. sugar of figs, sugar of grapes, starch sugar, the mushroom sugar of Braconnot, manna, sugar of gelatin, sugar of honey, and sugar of diabetes.

Sugar of grapes does not affect a peculiar form. It is deposited, from its alcoholic solution, in small grains, which have little consistence, are grouped together, and which constitute tubercles, similar to those of cauliflowers. When put in the mouth, it produces at first a sensation of coolness, to which succeeds a saccharine taste, not very strong. Hence, to sweeten to an equal degree the same quantity of water, we must employ two and a half times as much sugar of grapes as of that of the cane. In other respects, it possesses all the properties of cane sugar. Its extraction is very easy. The expressed juice of the grapes is composed of water, sugar, mucilage, bitartrate of potash, tartrate of lime, and a small quantity of other saline matters. We pour into it an excess of chalk in powder, or rather of pounded marble. There results, especially on agitation, an effervescence, due to the unsaturated tartaric acid. The liquor is then clarified with whites of eggs or blood. It is next evaporated in copper pans, till it marks a density of 1·32 at the boiling temperature. It is now allowed to cool. At the end of some days, it concretes into a crystalline mass, which, when drained, washed with a little cold water, and strongly compressed, constitutes sugar.

In the south of France, where this operation was some years back carried on on the great scale, to prevent fermentation of the *must*, there was added to this a little sulphate of lime, or it was placed in tuns, in which sulphur matches had been previously made to burn. The oxygen of the small quantity of air left in the tuns being thus abstracted by the sulphurous acid, fermentation did not take place. By this means, the *must* can be preserved a considerable time; whereas, in the ordinary way, it would lose its saccharine taste at the end of a few days, and become vinous. *Must* thus treated is said to be *muted*. The syrup was evaporated to the density of only 1·285. — *Proust*, *Ann. de Chimie*, lvii. 131.; *and the Collection of Memoirs published by Parmentier in* 1813.

It is this species of sugar which is obtained from starch and woody fibre by the action of dilute sulphuric acid.

Sugar of diabetes has sometimes the sweetening force of sugar of grapes; occasionally much less.

Braconnot's mushroom sugar is much less sweet than that of the cane. It crystallizes with remarkable facility, forming long quadrilateral prisms with square bases. It yields alcohol by fermentation.

All honeys contain two species of sugar; one similar to sugar of the grape, another like the uncrystallizable sugar of the cane (melasses). These combined, and mingled in different proportions with an odorant matter, constitute the honeys of good quality. Those of inferior quality contain, besides, a certain quantity of wax and acid: the honeys of Britanny contain even an animal secretion (*couvain*) to which they owe their putrescent quality. A slight washing with a little alcohol separates the uncrystallizable sugar, and leaves the other, which may be purified by washing with a very little more alcohol.

"The relation," says Dr. Prout, "which exists between urea and sugar seems to explain in a satisfactory manner the phenomena of diabetes, which may be considered as a depraved secretion of sugar. The weight of the atom of sugar is just half that of the weight of the atom of urea; the absolute quantity of hydrogen in a given weight of both is equal; while the absolute quantities of carbon and oxygen in a given weight of sugar are precisely twice those of urea."

The constituents of these two bodies and lithic acid are thus expressed by that ingenious philosopher.

ELEMENTS.	UREA.			SUGAR.			LITHIC ACID.		
	No.	Per Atom.	Per Cent.	No.	Per Atom.	Per Cent.	No.	Per Atom.	Per Cent.
Hydrogen....	2	2·5	6·66	1	1·25	6·66	1	1·25	2·85
Carbon......	1	7·5	19·99		7·50	39·99	2	15·00	34·28
Oxygen......	1	10·0	26·66		10·00	53·33	1	10·00	22·85
Azote.......	1	17·5	46·66				1	17·50	40·00
	5	37·5	100·00	3	18·75	100·00	5	43·75	100·00

The above compounds appear to be formed by the union of more simple compounds, as sugar, of carbon and water; urea, of carburetted hydrogen and nitrous oxide; lithic acid, of cyanogen and water, &c. whence it is inferred, that their artificial formation falls within the limits of chemical operations.

SUGAR OF LEAD. Acetate of lead. See LEAD.

SULPHATES. Definite compounds of sulphuric acid with the salifiable bases. See ACID (SULPHURIC), and the respective bases.

SULPHATO-TRICARBONATE OF LEAD. A new mineral, found at Leadhills, whose peculiar nature was first pointed out by Mr. Brooke. Stromeyer has since confirmed Mr. Brooke's statement of its composition, as follows:

Carbonate of lead	72·7
Sulphate of lead	27·3

SULPHITES. Definite compounds of sulphurous acid with the bases.

SULPHUR. Of native or prismatic sulphur there are two species, the common and volcanic; the former is of two kinds, compact and earthy sulphur.

§ 1. *Compact common sulphur.* Colour sulphur-yellow, and yellow of other shades. Massive, disseminated, and crystallized. Its primitive figure is a pyramid of 107° 19′; and 84° 24′; basis = 102° 41′. The secondary figures are, the primitive variously truncated or acuminated, and delicate acicular crystals. Shining or glimmering. Cleavage prismatic and axifrangible. Fracture uneven. Translucent. Refracts double. Harder than talc. Brittle. When rubbed, it exhales a faint sulphureous smell, and becomes resino-electric. Sp. gr. 1·9 to 2·1. It occurs in considerable abundance in primitive mountains, in a state of combination with metals, forming the different genera of pyrites, glance, and blende. In secondary mountains it is more abundant in the pure uncombined state. It is found in the island of Iceland, associated with gypsum; or in crusts investing alluvial substances. Very superb specimens of crystallized sulphur are found at Conil near Cape Trafalgar. It occurs abundantly in Sicily, at Urbino in the Papal States, in Arragon in Spain, and Lauenstein in Hanover.

§ 2. *Earthy common sulphur.* Colour pale straw-yellow Massive and disseminated. Dull. Fracture fine earthy. Opaque. Does not soil. Soft to friable. It occurs in drusy cavities in flint, and along with the compact varieties in gypsum, and other rocks.

2. *Volcanic sulphur.* Colour pale sulphur-yellow. Massive, imitative, and crystallized in pyramids. Glistening, inclining to adamantine. Fracture uneven. Slightly translucent. It occurs abundantly at Solfaterra in the neighbourhood of Vesuvius, and in Iceland.—*Jameson.*

SULPHUR. A simple inflammable body, of great importance in chemistry and the arts. To the properties above mentioned we shall here add, that its fusing point is about 220° F., before which temperature it begins to evaporate. At 560° it takes fire in the open air, and burns with a pale blue flame. When kept melted in an open vessel for some time, about 300° F., it becomes thick and viscid; and if it be then poured into a basin of water, it appears of a red colour, and ductile like wax. In this state it is used for taking impressions of seals or medals. Its sp. gr. is said to be increased from 1·99 to 2·325. This change is not owing to oxidation, for it takes place in close vessels.

When a roll of sulphur is suddenly seized in a warm hand, it crackles, and sometimes falls in pieces. This is owing to the unequal action of heat, on a body which conducts that power slowly, and which has little cohesion. If a mass of sulphur be melted in a crucible, and after the surface begins to concrete, if the liquid matter below be allowed to run out, fine acicular crystals of sulphur will be obtained.

Sulphur is insoluble in water; but in small quantity in alcohol and ether, and more largely in oil.

Sulphur combines with oxygen in four definite proportions, constituting an interesting series of acids. See ACID (SULPHURIC).

From these combinations it is inferred, that the prime equivalent of sulphur is 2; and the density of its vapour is 1.111 = that of oxygen gas.

Sulphur combines readily with chlorine. This compound was first made by Dr. Thomson, who passed chlorine gas through flowers of sulphur. It may be made more expeditiously by heating sulphur in a retort containing chlorine. The sulphur and chlorine unite, and form a fluid substance, which is volatile below 200° F., and distils into the cold part of the retort. This substance, seen by reflected light, appears of a red colour, but is yellowish-green when seen by transmitted light. It smokes when exposed to air, and has an odour somewhat resembling that of sea-weed, but much stronger; it affects the eyes like the smoke of peat. Its taste is acid, hot, and bitter. Its sp. gr. is 1.7.

It does not redden perfectly dry paper tinged with litmus; when it is agitated in contact with water, the water becomes cloudy from the appearance of sulphur, and strongly acid, and it is found to contain oil of vitriol.

According to Sir H. Davy's experiments, 10 grains of pure sulphur absorb nearly 30 cubic inches of chlorine, so that the compound contains about 2 sulphur to 4.5 chlorine, or a prime equivalent of each.

The compound formed in the manner above described cannot be made to unite to more chlorine; but it can dissolve a considerable portion of sulphur by heat, and becomes of a tawny-yellow colour.

Iodide of sulphur is easily formed by mixing the two ingredients in a glass tube, and exposing them to such a heat as melts the sulphur. It is grayish-black, and has a radiated structure like that of sulphuret of antimony. When distilled with water, iodine is disengaged.

Sulphur and hydrogen combine. Their union may be effected, by causing sulphur to sublime in dry hydrogen in a retort. There is no change of volume; but only a part of the hydrogen can be united with the sulphur in this mode of operating.

The usual way of preparing sulphuretted hydrogen is to pour a dilute sulphuric or muriatic acid on the black sulphuret of iron or antimony in a retort. For accurate experiments it should be collected over mercury. It takes fire when a lighted taper is brought in contact with it, and burns with a pale blue flame, depositing sulphur. Its smell is extremely fetid, resembling that of rotten eggs. Its taste is sour. It reddens vegetable blues. It is absorbable by water, which takes up more than an equal volume of the gas. Its sp. gr. according to MM. Gay Lussac and Thenard, is to that of air as 1.1912 to 1.0. From Sir H. Davy's experiments, it would appear to be a little less, but he is inclined to adopt the results of the French chemists, rather than his own, as their gas was weighed in larger quantity, and dried. Notwithstanding this preference of other experiments to his own, we must prefer a number nearer to Sir H. Davy's than M. Gay Lussac's. Its true sp. gr. is 1.1805. 100 cubic inches weigh 36.006; and it consists of 1 volume vapour of sulphur = 1.1111 + 1 volume of hydrogen = 0.0694 = 1.1805; or a prime equivalent of each = 2.125. If platina wires be ignited in it, by the voltaic apparatus, it is rapidly decomposed. Sulphur is deposited, and an equal volume of hydrogen remains. The same change is effected more slowly by electric sparks.

M. Berthier recommends the following process for procuring pure sulphuretted hydrogen at an economical rate: powdered common iron pyrites is to be mixed with half its weight of dry carbonate of soda, and heated red hot in a crucible; a fused sulphuret of sodium and iron is obtained, which may be poured out on a stone to cool. It is then a homogeneous deep-yellow coloured mass, having a lamellar fracture. It absorbs much water, forming with it a black paste, which, when acted on by sulphuric or muriatic acid, instantly yields abundance of sulphuretted hydrogen; leaving a black sulphuret of iron, which, by the application of acid and heat, will yield a second portion of the gas.

Sulphuret of lime, made by decomposing the sulphate at a high heat, with one-fifth of its weight of charcoal, yields 46.8 *per cent.* of sulphuretted hydrogen, when acted on with dilute muriatic acid. *Ann. de Chimie*, xxiv. 271.

When a few drops of fuming nitric acid are put into a flask filled with pure sulphuretted hydrogen, the hydrogen is oxidized by the nitric acid, and the sulphur is disengaged in a solid form. If the flask be closed with the finger, so that the gas which becomes heated cannot escape, its temperature is raised so much as to produce combustion with a beautiful flame, and a slight detonation which forces the finger from the mouth of the flask. This experiment may be made without the least danger, with a flask containing four or five cubical inches of gas. *Berzelius.*

Of all the gases, sulphuretted hydrogen is perhaps the most deleterious to animal life. A greenfinch, plunged into air, which contains only $\frac{1}{1500}$ of its volume, perishes instantly.

A dog of middle size is destroyed in air that contains $\frac{1}{800}$; and a horse would fall a victim to an atmosphere containing $\frac{1}{250}$.

Dr. Chaussier proves, that to kill an animal, it is sufficient to make the sulphuretted hydrogen gas act on the surface of its body, when it is absorbed by the inhalants. He took a bladder having a stop-cock at one end, and at the other an opening, into which he introduced the body of a rabbit leaving its head outside, and securing the bladder air-tight round the neck by adhesive plaster. He then sucked the air out of the bladder, and replaced it by sulphuretted hydrogen gas. A young animal in these circumstances usually perishes in 15 or 20 minutes. Old rabbits resist the poison much longer.

When potassium or sodium is heated, merely to fusion, in contact with sulphuretted hydrogen, it becomes luminous, and burns with extrication of hydrogen, while a metallic sulphuret remains, combined with sulphuretted hydrogen, or a sulphuretted hydrosulphuret.

Sulphuretted hydrogen combines with an equal volume of ammonia, and unites to alkalis and oxides, so that it has all the characters of an acid. These compounds are called *hydrosulphurets.*

All the *hydrosulphurets*, soluble in water, have an acrid and bitter taste, and, when in the liquid state, the odour of rotten eggs. All those which are insoluble are, on the contrary, insipid, and without smell. There are only two coloured hydrosulphurets, that of iron, which is black, and of antimony, which is chestnut-brown.

All the hydrosulphurets are decomposed by the action of fire. That of magnesia is transformed into sulphuretted hydrogen and oxide of magnesium; those of potash and soda, into sulphuretted hydrogen, hydrogen, and sulphuretted alkalis; those of manganese, zinc, iron, tin, and antimony, into water and metallic sulphurets.

When we put in contact with the air, at the ordinary temperature, an aqueous solution of a hydrosulphuret, there results, in the space of some days, 1st, water, and a sulphuretted hydrosulphuret, which is yellow and soluble; 2d, water, and a colourless hydrosulphite, which, if its base be potash, soda, or ammonia, remains in solution in the water; but which falls down in acicular crystals, if its base be barytes, strontia, or lime.

The acids in general combine with the base of the hydrosulphurets, and disengage sulphuretted hydrogen with a lively effervescence, without any deposition of sulphur, unless the acid be in excess, and be capable, like the nitric and nitrous acid, of yielding a portion of its oxygen to the hydrogen of the sulphuretted hydrogen.

The hydrosulphurets of potash, soda, ammonia, lime, and magnesia, are prepared directly, by transmitting an excess of sulphuretted hydrogen gas through these bases, dissolved or diffused in water.

The composition of the hydrosulphurets is such, that the hydrogen of the sulphuretted hydrogen is to the oxygen of the oxide in the same ratio as in water. Hence, when we calcine the hydrosulphurets of iron, tin, &c. we convert them into water and sulphurets.

Hydrosulphuret of potash crystallizes in four-sided prisms, terminated by four-sided pyramids. Its taste is acrid and bitter. Exposed to the air, it attracts humidity, absorbs oxygen, passes to the state of a sulphuretted hydrosulphuret, and finally to that of a hydrosulphite. It is extremely soluble in water. Its solution in this liquid occasions a perceptible refrigeration. Subjected to heat, it evolves much sulphuretted hydrogen, and the hydrosulphuret passes to the state of a sub-hydrosulphuret.

Hydrosulphuret of soda crystallizes with more difficulty than the preceding.

Hydrosulphuret of ammonia is obtained by the direct union of the two gaseous constituents in a glass balloon, at a low temperature. As soon as the gases mingle, transparent white or yellowish crystals are formed. When a mere solution of this hydrosulphuret is wished for medicine or analysis, we pass a current of sulphuretted hydrogen through aqueous ammonia till saturation.

The pure hydrosulphuret is white, transparent, and crystallized in needles or fine plates. It is very volatile. Hence, at ordinary temperatures, it gradually sublimes into the upper part of the phials in which we preserve it. We may also by the same means separate it from the yellow sulphuretted hydrosulphuret, with which it is occasionally mixed. When exposed to the air, it absorbs oxygen, passes to the state of a sulphuretted hydrosulphuret, and becomes yellow. When it contains an excess of ammonia, it dissolves speedily in water, with the production of a very considerable cold.

Sub-hydrosulphuret of barytes is prepared by dissolving, in five or six parts of boiling water, the sulphuret of the earth obtained by igniting the sulphate with charcoal. The solution being filtered while hot, will deposit, on cooling, a multitude of crystals, which must be drained, and speedily dried by pressure between the folds of blotting paper. It crystallizes in white scaly plates. It is much more soluble in hot than in cold water. Its solution is colourless, and capable of absorbing, at the ordinary temperature, a very large quantity of sulphuretted hydrogen.

Sub-hydrosulphuret of strontites crystallizes in the same manner as the preceding. The crystals obtained in the same way must be dissolved in water; and the solution being exposed to a stream of sulphuretted hydrogen, and then concentrated by evaporation in a retort. will afford, on cooling, crystals of pure sub-hydrosulphuret.

Hydrosulphurets of lime and magnesia have been obtained only in aqueous solutions. The metallic hydrosulphurets of any practical importance are treated of under their respective metals.

When we expose sulphur to the action of a solution of a hydrosulphuret, saturated with sulphuretted hydrogen, as much more sulphuretted hydrogen is evolved as the temperature is more elevated. But when the solution of hydrosulphuret, instead of being saturated, has a sufficient excess of alkali, it evolves no perceptible quantity of sulphuretted hydrogen, even at a boiling heat; although it dissolves as much sulphur as in its state of saturation. It hence follows, 1st, That sulphuretted hydrogen, sulphur, and the alkalis, have the property of forming very variable triple combinations; 2d, That all these combinations contain less sulphuretted hydrogen than the hydrosulphurets; and, 3d, That the quantity of sulphuretted hydrogen is inversely as the sulphur they contain, and reciprocally. These compounds have been called, in general, sulphuretted hydrosulphurets; but the name of hydrogenated sulphurets is more particularly given to those combinations which are saturated with sulphur at a high temperature, because, by treating them with acids, we precipitate a peculiar compound of sulphur and hydrogen, of which we shall now treat.

This compound of hydrogen and sulphur, the proportions of the elements of which have not yet been accurately ascertained, is also called hydruret of sulphur. It is formed by putting flowers of sulphur in contact with nascent sulphuretted hydrogen. With this view, we take an aqueous solution of the hydrogenated sulphuret of potash, and pour it gradually into liquid muriatic acid, which seizes the potash, and forms a soluble salt, whilst the sulphur and sulphuretted hydrogen unite, fall down together, collecting by degrees at the bottom of the vessel, as a dense oil does in water. To preserve this hydruret of sulphur, we must fill with it a phial having a ground stopper, cork it, and keep it inverted in a cool place. We may consider this substance either as a combination of sulphur and hydrogen, or of sulphur and sulphuretted hydrogen; but its properties, and the mode of obtaining it, render the latter the more probable opinion. The proportion of the constituents is not known.

The most interesting of the hydrogenated sulphurets is that of ammonia. It was discovered by the Hon. Robert Boyle, and called his fuming liquor. To prepare it, we take one part of muriate of ammonia and of pulverized quicklime, and half a part of flowers of sulphur. After mixing them intimately, we introduce the mixture into an earthen or glass retort, taking care that none of it remains in the neck. A dry cooled receiver is connected to the retort by means of a long adopter-tube. The heat must be urged slowly almost to redness. A yellowish liquor condenses in the receiver, which is to be put into a phial with its own weight of flowers of sulphur, and agitated with it seven or eight minutes. The greater part of the sulphur is dissolved, the colour of the mixture deepens remarkably, and becomes thick, constituting the hydrogenated sulphuret.

The distilled liquor diffuses, for a long time, dense vapour in a jar full of oxygen or common air; but scarcely any in azote or hydrogen; and the dryness or humidity of the gases makes no difference in the effects. It is probably owing to the oxygen converting the liquor into a hydrogenated sulphuret, or perhaps to the state of sulphite, that the vapours appear.

Hydrogenated sulphurets are frequently called hydroguretted sulphurets.

Sulphur combines with carbon, forming an interesting compound, to which the name of sulphuret of carbon is sometimes given. I have described it under the title CARBURET OF SULPHUR. For the combinations of sulphur and phosphorus, see the latter article.

SULPHURETS OF ALKALIS AND EARTHS. Heretofore these were reckoned compounds of the alkalis and earths themselves with sulphur, that is, sulphuretted oxides; but M. Berthier has proved that they are all true metallic sulphurets. He reduces the sulphates of alkalis into sulphurets, not by mixing them directly with powdered charcoal, but by placing them in the centre of a crucible, thickly lined with charcoal, covering them with the same substance, and after having luted on a cover, heating the whole in a furnace. In this way the sulphates are reduced by cementation. All are reducible at a white heat, and where the sulphuret is fusible very quickly. In this way not only are pure sulphurets formed, but the result may be collected without the smallest loss, its weight ascertained, and the weight of oxygen evolved accurately estimated.

If a sulphate of barytes, strontites, or lime be thus reduced to a sulphuret, and weighed, the loss will be found to equal exactly the quantity of oxygen contained in the base and the acid. If the sulphuret be dissolved in dilute muriatic acid, nothing will be liberated but pure sulphuretted hydrogen; no sulphur will be set free, nor any acid containing sulphur and oxygen formed; finally, if a portion of the sulphuret be heated in a crucible of silver, with nitre equal to three or four times its weight, the sulphate regenerated will correspond with the quantity of sulphuret employed, and will contain neither acid nor base in excess. These three experiments prove that the sulphuret produced contains no oxygen, and consequently that the base is in the metallic state. *Journ. des Mines*, vii. 421.

SULPHURETTED CHYAZIC ACID. See Acid (Sulphuroprussic).

SULPHURIC ACID. See Acid (Sulphuric).

SULPHUROUS ACID. See Acid (Sulphurous).

SUMACH. Common sumach (rhus coriaria) is a shrub that grows naturally in Syria, Palestine, Spain, and Portugal. In the two last, it is cultivated with great care. Its shoots are cut down every year quite to the root; and, after being dried, they are reduced to powder by a mill, and thus prepared for the purposes of dyeing and tanning. The sumach cultivated in the neighbourhood of Montpellier is called *rédoul*, or *roudou*.

Mr. Hatchett found, that an ounce contains about 78 or 79 grains of tannin.

Sumach acts on a solution of silver just as galls do; it reduces the silver to its metallic state, and the reduction is favoured by the action of light.

Of all astringents sumach bears the greatest resemblance to galls. The precipitate, however, produced in solutions of iron by an infusion of it, is less in quantity than what is obtained by an equal weight of galls; so that in most cases it may be substituted for galls, the price of which is considerable, provided we proportionally increase its quantity.

Sumach alone gives a fawn colour, inclining to green; but cotton stuffs, which have been impregnated with printer's mordant, that is, acetate of alumina, take a pretty good and very durable yellow. An inconvenience is experienced in employing sumach in this way, which arises from the fixed nature of its colour; the ground of the stuff does not lose its colour by exposure on the grass, so that it becomes necessary to impregnate all the stuff with different mordants, to vary the colours, without leaving any part of it white.

SUPERSALT. A compound of an acid and base, in which the acid is in excess. See Subsalt.

SUPERSALTS. Salts with excess of acid.

SURTURBRAND. Fibrous brown coal or bituminous wood, so called in Iceland, where it occurs in great quantities.

SWAMP ORE. Indurated bog iron ore.

SWEAT. When the temperature of the body is much increased, either by being exposed to a hot atmosphere or by violent exercise, the perspired vapour not only increases in quantity, but even appears in a liquid form. This is known by the name of *sweat*.

Beside water, it cannot be doubted that *carbon* is also emitted from the skin; but in what state, the experiments hitherto made do not enable us to decide. Mr. Cruickshanks found, that the air of the glass vessel in which his hand and foot had been confined for an hour, contained carbonic acid gas; for a candle burned dimly in it, and it rendered lime water turbid. And Mr. Jurine found that air which had remained for some time in contact with the skin, consisted almost entirely of carbonic acid gas. The same conclusion may be drawn from the experiments of Ingenhousz and Milly. Trousset has lately observed, that air was separated copiously from a patient of his, while bathing.

Beside water and carbon, or carbonic acid gas, the skin emits also a particular odorous substance. That every animal has a peculiar smell is well known: the dog can discover his master, and even trace him to a distance by the scent. A dog, chained up several hours after his master had set out on a journey of some hundred miles, followed his footsteps by the smell. But it is needless to multiply instances of this fact; they are too well known to every one. Now this smell must be owing to some peculiar matter, which is constantly emitted; and this matter must differ somewhat, either in quantity or some other property, as we see that the dog easily distinguishes the individual by means of it. Mr. Cruickshanks has made it probable, that this matter is an oily substance; or at least that there is an oily substance emitted by the skin. He wore repeatedly, night and day for a month, the same under waistcoat of fleecy hosiery, during the hottest part of the summer. At the end of this time he always found an oily substance accumulated in considerable masses on the nap of the inner surface of the waistcoat, in the form of black tears. When rubbed on paper it rendered it transparent, and hardened on it like grease. It burned with a white flame, and left behind it a charry residuum.

Berthollet has observed the perspiration acid; and he has concluded, that the acid which is present is the phosphoric; but this has not been proved. Fourcroy and Vauquelin have ascertained, that the scurf which collects upon the skins of horses consists chiefly of phosphate of lime, and urea is even sometimes mixed with it.

According to Thenard, however, who has lately endeavoured more particularly to ascertain this point, the acid contained in sweat is the acetous; which, he likewise observes, is the only free acid contained in urine and in milk, this acid existing in both of them when quite fresh. His account of his examination of it is as follows:—

The sweat is more or less copious in different individuals; and its quantity is perceptibly in the inverse ratio of that of the urine. All other circumstances being similar, much more is produced during digestion than during repose. The maximum of its production appears to be twenty-six grains and two-thirds in a minute; the minimum nine grains, troy weight. It is much inferior, however, to the pulmonary transpiration; and there is likewise a great difference between their nature and manner of formation. The one is a product of a particular secretion, similar in some sort to that of the urine; the other, composed of a great deal of water and carbonic acid, is the product of a combustion gradually effected by the atmospheric air.

The sweat, in a healthy state, very sensibly reddens litmus paper or infusion. In certain diseases, and particularly in putrid fevers, it is alkaline; yet its taste is always rather saline, and more similar to that of salt than acid. Though colourless, it stains linen. Its smell is peculiar, and insupportable when it is concentrated, which is the case in particular during distillation. But before he speaks of the trials to which he subjected it, and of which he had occasion for a great quantity, he describes the method he adopted for procuring it, which was similar to that of Mr. Cruickshanks.

Human sweat, according to M. Thenard, is formed of a great deal of water; free acetous acid; muriate of soda; an atom of phosphate of lime, and oxide of iron; and an inappreciable quantity of animal matter, which approaches much nearer to gelatin than to any other substance.

SWINESTONE. A variety of compact lucullite, a sub-species of limestone.

SYLVANITE. Native tellurium.

SYLVIUS (SALT OF) or FEBRIFUGE (SALT OF). Muriate of potash.

SYNOVIA. Within the capsular ligament of the different joints of the body there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomists by the name of *synovia*.

From the analysis of M. Margueron, it appears that synovia is composed of the following ingredients:

11·86	fibrous matter
4·52	albumen
1·75	muriate of soda
·71	soda
·70	phosphate of lime
80·46	water
100·00	

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TABASHEER. The silica which is found in the hollow stem of the bamboo is so named. Its optical properties are peculiar. They have been described by Dr. Brewster, *Phil. Trans.* 1819.

TABULAR SPAR, or TABLE SPAR. The schaalstein of Werner, and prismatic augite of Jameson.

Colour grayish-white. Massive, and in angular-granular concretions. Shining pearly. Cleavage double. Fracture splintery. Translucent. Harder than fluor spar, but not so hard as apatite. Brittle. Sp. gr. 3·2 to 3·5. Its constituents are, silica 50, lime 45, water 5.—*Klaproth.* It occurs in primitive rocks, at Orawicza in the Bannat of Temeswar, where it is associated with brown garnets.

TACAMAHAC. A resin, having the aroma of musk, and soluble in alcohol.

TALC. Of this mineral, Professor Jameson's sixth sub-species of rhomboidal mica, there are two kinds; common talc, and indurated talc.

1. *Common talc.* Colour greenish-white. Massive, disseminated in plates, imitative, and sometimes crystallized in small six-sided tables which are druses. Splendent, pearly, semi-metallic. Cleavage single, with curved folia. Translucent. Flexible, but not elastic. Yields to the nail. Perfectly sectile. Feels very greasy. Sp. gr. 2·77. It whitens, and at length affords a small globule of enamel, before the blowpipe. Its constituents are, silica 62, magnesia 27, alumina 1.5, oxide of iron 3·5, water 6.—*Vauquelin.* Klaproth found 2·75 of potash in 100 parts. It occurs in beds in mica-slate and clay-slate. It is found in Aberdeenshire, Banffshire, and Perthshire. The finest specimens come from Saltzburg, the Tyrol, and St. Gothard. It is an ingredient in rouge for the toilette, along with carmine and benzoin. This cosmetic communicates a remarkable degree of softness to the skin, and is not injurious. The flesh polish is given to gypsum figures, by rubbing them with talc.

2. *Indurated talc*, or *talc-slate.* Colour greenish-gray. Massive. Fragments tabular. Translucent on the edges. Soft. Streak white. Rather sectile. Easily frangible. Not flexible. Feels greasy. Sp. gr. 2·7 to 2·8. It occurs in primitive mountains, where it forms beds in clay-slate and serpentine. It is found in Perthshire, Banffshire, the Shetland Islands, and abundantly on the continent. It is employed for drawing lines by carpenters, tailors, hat-makers, and glaziers.—*Jameson.*

TALCITE. Nacrite of Jameson, and earthy talc of Werner. Colour greenish-white. It consists of scaly parts. Glimmering, pearly. Friable. Feels very greasy. Soils. It melts easily before the blowpipe. Its constituents are, alumina 81·75, magnesia 0·75, lime 4, potash 0·5, water 13·5.—*John.* This is a very rare mineral, occurring in veins, with sparry ironstone and galena, in the mining district of Freyberg.

TALLOW. See FAT.

TALLOW (MOUNTAIN). Specimens of this substance were lately found in a bog on the borders of Loch Fyne in Scotland. This curious mineral was first observed by some peasants on the coast of Finland in 1736; and it was afterwards found in one of the Swedish lakes. It has the colour and feel of tallow; and is tasteless. It melts at 118° F. and boils at 290°. When melted it is transparent and colourless, on cooling it becomes opaque and white, though less so than at first. It is insoluble in water, but soluble in hot alkohol, oil of turpentine, olive oil, and naphtha; but precipitates as these liquids cool. Its sp. grav. in the natural state is 0·6078, but it is then full of air bubbles. After fusion, its density is 0·983, which is something above ordinary tallow. It does not combine with alkalis nor form soap. Thus it differs from every class of bodies known. From the fixed oils, in not saponifying; from the volatile oils and bitumen, in being tasteless and destitute of smell. In volatility and combustibility it resembles naphtha.—*Edin. Phil. Journ.* xi. 214.

TALLOW (PINEY). A concrete inflammable substance, obtained by boiling in water the fruit of the *Vateria Indica*, a tree common on the Malabar coast. It partakes of the nature of both wax and oil, and from its appearance may not inaptly be termed a tallow. It is employed in the town of Mangalore as an external application for bruises and rheumatic pains. It melts at 97½° F.; is generally white, sometimes yellow, and is greasy to the touch with some degree of waxiness. Sp. gr. 0·926 at 60°. It is not soluble in alcohol, which takes merely 2 *per cent.* of elain. Fixed alkalis saponify it. It forms excellent candles, coming freely from the mould. Its ultimate constituents are,

Carbon, 77·0 = 10 atoms.
Hydrogen, 12·3 = 9
Oxygen, 10·7 = 1

Dr. Babington, in Journal of Science, xix. 177.

TAMARINDS. The pulp consists, according to Vanquelin, of bitartrate of potash 300, gum 432, sugar 1152, jelly 576, citric acid 864, tartaric acid 144, malic acid 40, feculent matter 2880, water 3364; in 9752 parts.

TANNIN. This, which is one of the immediate principles of vegetables, was first distinguished by Seguin from the gallic acid, with which it had been confounded under the name of the *astringent principle*. He gave it the name of tannin, from its use in the tanning of leather; which it effects by its characteristic property, that of forming with gelatin a tough insoluble matter.

It may be obtained from vegetables by macerating them in cold water; and precipitated from this solution, which contains likewise gallic acid and extractive matter, by hyperoxygenized muriate of tin. From this precipitate, immediately diffused in a large quantity of water, the oxide of tin may be separated by sulphuretted hydrogen gas, leaving the tannin in solution.

Professor Proust has since recommended another method, the precipitation of a decoction of galls by powdered carbonate of potash, washing well the greenish-gray flakes that fall down with cold water, and drying them in a stove. The precipitate grows brown in the air, becomes brittle and shining like a resin, and yet remains soluble in hot water. The tannin in this state, he says, is very pure.

Sir H. Davy, after making several experiments on different methods of ascertaining the quantity of tannin in astringent infusions, prefers for this purpose the common process of precipitating the tannin by gelatin; but he remarks, that the tannin of different vegetables requires different proportions of gelatin for its saturation; and that the quantity of precipitate obtained is influenced by the degree in which the solutions are concentrated.

M. Chenevix observed, that coffee berries acquired by roasting the property of precipitating gelatin; and Mr. Hatchett has made a number of experiments, which show that an artificial tannin, or substance having its chief property, may be formed, by treating with nitric acid matters containing charcoal. It is remarkable that this tannin, when prepared from vegetable substances, as dry charcoal of wood, yields, on combustion, products analogous to those of animal matters. From his experiments it would seem, that tannin is, in reality, carbonaceous matter combined with oxygen; and the difference in the proportion of oxygen may occasion the differences in the tannin procured from different substances, that from catechu appearing to contain most.

Bouillon Lagrange asserts, that tannin by absorbing oxygen is converted into gallic acid.

It is not an unfrequent practice, to administer medicines containing tannin in cases of debility, and at the same time to prescribe gelatinous food as nutritious. But this is evidently improper, as the tannin, from its chemical properties, must render the gelatin indigestible. For the chief use of tannin, see the following article.

According to Berzelius, tannin consists of hydrogen 4·186 + carbon 51·160 + oxygen 44·654. And the tannate of lead is composed of,

Tannin,	100	26·923
Oxide of lead,	52	14·

But there is much uncertainty concerning the definite neutrality of this compound.

TANNING. The several kinds of leather are prepared from the skins of animals macerated for a long time with lime and water, to promote the separation of the hair and wool, and of the fat and fleshy parts, in which recourse is also had to the assistance of mechanical pressure, scraping, and the like. The skin, when thus deprived of its more putrescible part, and brought considerably toward the state of mere fibre, is tanned by maceration with certain astringent substances, particularly the bark of the oak-tree.

The hide consists almost wholly of gelatin, and all that is necessary is, to divest it of the hair, epidermis, and any flesh or fat adhering to it. This is commonly done, after they have been soaked in water some time, and handled or trodden to cleanse them from filth, by immersing them in milk of lime. Some, instead of lime, use an acescent infusion of barley or rye-meal, or spent tan; and others recommend water acidulated with sulphuric acid. Similar acidulous waters are afterward employed for raising or swelling the hide, when this is necessary.

The skins, thus prepared, are finally to undergo what is properly called the tanning. This is usually done by throwing into a pit, or cistern made in the ground, a quantity of ground oak-bark that has already been used, and on this the skins and fresh bark in alternate layers, covering the whole with half a foot of tan, and treading it well down. The tanning may be accelerated by adding a little water.

As it is a long time before the hide is thoroughly tanned in this mode, at least many months, during which the bark is renewed three or four times; M. Seguin steeps the skins in a strong infusion of tan, and assists its action by heat. Chaptal observes, however, that this requires an extensive apparatus for preparing the liquor and the skins: the leather imbibes so much water, that it remains spongy a long time, and wrinkles in drying; and it is extremely difficult so to arrange the hides in a copper, as to keep them apart from each other, and free of the sides of the vessel.

The following account of M. Seguin's practice was transmitted to England in the year 1796:—

To tan a skin is to take away its putrescent quality, preserving, however, a certain degree of pliability. This is effected by incorporating with the skin particles of a substance which destroys their tendency to putrefaction.

The operations relating to tanning are therefore of two kinds:—the first is merely depriving the skin of those parts which would oppose its preservation, or which adhere to it but little, such as hair and flesh; the other consists in incorporating with it a substance, which shall prevent its putrefying.

The operations of the first kind are technically termed, unhairing and fleshing; the operations of the second kind belong to tanning, properly so called.

Fleshing is an operation merely mechanical: unhairing is a mechanical operation if performed by shaving; or a chemical operation, if effected by dissolution or decomposition of the substance which connects the hair with the skin.

According to the ancient method, the dissolution of this substance was effected by means of lime: the decomposition either by the vinous fermentation of barley, by the acetous fermentation of oak-bark, or by the putrid fermentation produced by piling the hides one upon another.

Unhairing by means of lime would often take twelve or fifteen months; this operation with barley, or the acetous part of tan, could not be performed in less than two months.

The slowness of these operations, which the experiments of Seguin have shown may be finished in a few days, and in a more advantageous manner, by means of the same substances, proves, that the nature of those operations was not understood by those who performed them. Those of tanning, properly so called, were as little known, as the details we are about giving will prove, which we compare with the least improved routine now in practice.

Whatever the method of unhairing was, the mode of tanning was always the same, for skins unhaired with lime, or those prepared with barley or tan.

This mode of operating would take eighteen months or two years, often three years, when it was wished to tan the hides thoroughly.

Among the substances for tanning gall-nut, sumach, and the bark of oak, to which may be added catechu, appear the most proper, at least, in the present state of our knowledge. In the middle departments of France, oak-bark is preferred, because it is the cheapest and most abundant substance. To use it, it is first ground to powder; then, according to the old mode, it is put into large holes dug in the ground, which are filled by alternate layers of ground bark and unhaired hides.

As the principle which effects the tanning cannot act in the interior of the skin, unless carried in by some liquid in which it is first dissolved, tanning is not produced by the immediate action of the powdered bark upon the skin, but only by the action of the dissolution of the tanning principle originally contained in the bark. The tan therefore has the tanning property only when wetted so much as not to absorb all the water thrown on it. But as tanners put in their vats only a small portion of water compared to what would be necessary to deprive the bark of all the tanning principle which it contains, the bark put into the vats preserves, when taken out, a portion of its tanning principle.

This waste is not the only disadvantage of the old modes of proceeding; they are, besides, liable never to produce in the skins a complete saturation with the tanning principle. For, as the property of attraction is common to all bodies, according to the different degree of saturation, the water containing in solution a certain quantity of the tanning principle, will not part, to a fixed weight of skins, with as much as the same quantity of water will, in which a greater quantity of the principle is dissolved.

As the water which, in the old manner of proceeding, is in the vats, can contain but a small portion of the tanning principle, owing to the nature of the operation, it can give but a small portion of it to the skin, and even this it parts with by slow degrees. Hence, the slowness in the tanning of skins, according to the old method, which required two whole years, and sometimes three, before a skin was well tanned to the centre. Hence also, the imperfection of skins tanned by that method; an imperfection resulting from the non-saturation of the tanning principle, even when it had penetrated the centre.

The important desideratum was, therefore, to get together, within a small compass, the tanning principle, to increase its action, and produce in the hide a complete saturation in a much shorter time than that necessary for the incomplete tanning produced in vats. But, first of all, it was necessary to analyse the skin, analyse the leather, and analyze the oak-bark. The principles of these three substances were to be insulated, and their action upon one another determined, the influence of their combination upon that action known, and the circumstances most productive of its greatest action found out.

Seguin, by following this method, has determined:—

1. That the skin deprived of flesh and hair is a substance which can easily, by a proper process, be entirely converted into an animal jelly (glue).

2. That a solution of this last mentioned substance, mixed with a solution of tan, forms immediately an imputrescible and indissoluble compound.

3. That the solution of tan is composed of two very distinct substances; one of which precipitates the solution of glue, and which is the true tanning substance; the other, which precipitates sulphate of iron, without precipitating the solution of glue, and which produces only the necessary disoxygenation of the skin, and of the substance which connects the hair to the skin.

4. That the operation of tanning is not a simple combination of the skin with the principle which precipitates the glue, but a combination of that principle with the skin disoxygenised by the substance, which in the solution of tan is found to precipitate the sulphate of iron; so that every substance proper for tanning should possess the properties of precipitating the solution of glue, and of precipitating the sulphate of iron.

5. That the operation of tanning consists in swelling the skins by means of an acidulous principle; to disoxygenize, by means of the principle which in the solution of bark precipitates the solution of sulphate of iron, that substance which connects the hair to the skin, and thus produce an easy unhairing; to disoxygenize the skin by means of the same principle, and to bring it by this disoxygenation to the middle state between glue and skin; and then to combine with it, after this disoxygenation, and while it is in this middle state, that particular substance in oak-bark, as well as in many other vegetables, which is found to precipitate the solution of glue, and which is not, as has been hitherto conceived, an astringent substance.

Agreeably to these discoveries, there only remains, in order to tan speedily and completely, to condense the tanning principle so as to accelerate its action. Seguin, to effect this, follows a very simple process. He pours water upon the powdered tan, contained in an apparatus nearly similar to that made use of in saltpetre works. This water, by going through the tan, takes from it a portion of its tanning principle, and by successive filtrations dissolves every time an additional quantity of it, till at last the bark rather tends to deprive it of some than to give up more. Seguin succeeds in bringing these solutions to such a degree of strength, that, he says, he can, by taking proper measure, tan calf-skin in 24 hours, and the strongest ox-hides in seven or eight days. These solutions containing a great quantity of the tanning principle, impart to the skin as much of it as it can absorb, so that it can then easily attain a complete saturation of the principle, and produce leather of a quality much superior to that of most countries famous for their leather.

On the above I have only to remark, that every new art or considerable improvement must unavoidably be attended with many difficulties in the establishment of a manufactory in the large way. From private inquiry I find, that this also has its difficulties, which have hitherto prevented its being carried into full effect in this country. Of what nature these may be I am not decidedly informed, and mention them in this place only to prevent manufacturers from engaging in an undertaking of this kind, without cautious inquiry.

M. Desmond has recommended, to saturate water with tannin, by affusion on successive portions of oak-bark, or whatever may be used; and when the bark will give out no more tannin, to extract what gallic acid still remains in it, by pouring on fresh water. To the latter, or acidulous liquor, he adds one-thousandth part by measure of sulphuric acid; and in this steeps the hide, till the hair will come off easily by scraping. When raising is necessary, he steeps the hide ten or twelve hours in water acidulated with a five-hundredth part by measure of sulphuric acid; after which they are to be washed repeatedly, and scraped with the round knife. Lastly, the hides are to be steeped some hours in a weak solution of tannin, then a few days in a stronger, and this must be renewed as the tannin is exhausted, till the leather is fully tanned.

For the softer skins, as calves, goats, &c., he does not use the acid mixture, but milk of lime.

Of substances used for tanning Sir H. Davy observes, that 1 lb. of catechu is nearly equal to 2½ of galls, 3 of sumach, 7½ of the bark of the Leicester willow, 8½ of oak-bark, 11 of the bark of the Spanish chestnut, 18 of elm-bark, and 21 of common willow-bark, with respect to the tannin contained in them. He observes too, that leather slowly tanned in weak infusions of barks appears to be better in quality, being both softer and stronger than when tanned by strong infusions; and he ascribes this to the extractive matter they imbibe. This principle, therefore, affects the quality of the material employed in tanning; and galls, which contain a great deal of tannin, make a hard leather, and liable to crack, from their deficiency of extractive matter.—*Ann. de Chim. et de Phys.*—*Philos. Trans.*—*Philos. Mag.*—*Chaptal's Chem.*

TANTALUM ORE. See Ore of Tantalum.

TANTALUM. The metal already treated of under the name Columbium.

TAPIOCA. A species of starch, prepared from the jatropha manchat. See Cassava.

TARRAS, or TERRAS. A volcanic earth used as a cement. It does not differ much in its principles from puzzolana; but it is much more compact, hard, porous, and spongy. It is generally of a whitish-yellow colour, and contains more heterogeneous particles, as spar, quartz, schorl, &c. and something more of a calcareous earth. It effervesces with acids, is magnetic, and fusible *per se*. When pulverized, it serves as a cement, like puzzolana. It is found in Germany and Sweden. See Lime, Cement, and Puzzolana.

TARTAR is deposited on the sides of casks during the fermentation of wine; it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from 10 to 15 livres the quintal.

All wines do not afford the same quantity of tartar. Neumann remarked, that the Hungarian wines left only a thin stratum; that the wines of France afforded more; and that the Rhenish wines afforded the purest and the greatest quantity.

Tartar is distinguished from its colour into red and white: the first is afforded by red wine.

Tartar is purified from an abundant extractive principle, by processes which are executed at Montpellier and at Venice.

The following is the process used at Montpellier:—The tartar is dissolved in water, and suffered to crystallize by cooling. The crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrate of potash.

M. Desmaretz has informed us, that the process used at Venice consists,

1. In drying the tartar in iron boilers.

2. Pounding it, and dissolving it in hot water, which, by cooling, affords purer crystals.

3. Redissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product. See Acid (Tartaric).

TARTAR (CHALYBEATED). This is prepared by boiling three parts of the supertartrate of potash and two of iron filings in forty-six parts of water, till the tartar appears to be dissolved. The liquor is then filtered, and crystals are deposited on cooling, more of which are obtained by continuing the evaporation.

TARTAR (CREAM OF). The popular name of the purified supertartrate of potash.

TARTAR (CRUDE). The supertartrate of potash in its natural state, before it has been purified.

TARTAR (EMETIC). The tartrate of potash and antimony. See Antimony.

TARTAR OF THE TEETH. The popular name for the concretion that so frequently incrusts the teeth, and which consists apparently of phosphate of lime.

TARTAR (REGENERATED). Acetate of potash.

TARTAR (SALT OF). The subcarbonate of potash.

TARTAR (SECRET FOLIATED EARTH OF). Acetate of potash.

TARTAR (SOLUBLE). Neutral tartrate of potash.

TARTAR (VITRIOLATED). Sulphate of potash.

TARTARINE. The name given by Kirwan to the vegetable alkali, or potash.

TARTAROUS ACID. See Acid (Tartaric).

TARTRATE. A neutral compound of the tartaric acid with the base.

TEA. The following interesting results of experiments on tea by Mr. Brande have been published by him in his Journal, xii. 206.

One hundred parts of Tea.	Soluble in water.	Soluble in Alcohol.	Precipit. with Jelly.	Inert residue.
Green Hyson, 14*s.* per lb.	41	44	31	56
Ditto, - 12*s.*	34	43	29	57
Ditto, - 10*s.*	36	43	26	57
Ditto, - 8*s.*	36	42	25	58
Ditto, - 7*s.*	31	41	24	59
Black Souchong, 12*s.*	35	36	28	64
Ditto, - 10*s.*	34	37	28	63
Ditto, - 8*s.*	37	35	28	63
Ditto, - 7*s.*	36	35	24	64
Ditto, - 6*s.*	35	31	23	65

TEARS. That peculiar fluid which is employed in lubricating the eye, and which is emitted in considerable quantities when we express grief by weeping, is known by the name of *tears.* For an accurate analysis of this fluid we are indebted to Messrs. Fourcroy and Vauquelin.

The liquid called tears is transparent and colourless like water; it has scarcely any smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper stained with the juice of the petals of mallows or violets a permanently green colour, and therefore contains a fixed alkali. It unites with water, whether cold or hot, in all proportions. Alkalis unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it. Exposed to the air, this liquid gradually evaporates and becomes thicker. When nearly reduced to a state of dryness, a number of cubic crystals form in the midst of a kind of mucilage. These crystals possess the properties of muriate of soda; but they tinge vegetable blues green, and therefore contain an excess of soda. The mucilaginous matter acquires a yellowish colour as it dries.

Tears are composed of the following ingredients:—

1. Water,
2. Mucus,
3. Muriate of soda,
4. Soda,
5. Phosphate of lime,
6. Phosphate of soda.

The saline parts amount only to about 0·01 of the whole, or probably not so much.

TEETH. The basis of the substance that forms the teeth, like that of other bones, (see BONE), appears to be phosphate of lime. The enamel, however, according to Mr. Hatchett, differs from other bony substances in being destitute of cartilage: for raspings of enamel, when macerated in diluted acids, he found were wholly dissolved; while raspings of bone, treated in the same manner, always left a cartilaginous substance untouched. See BONE.

TELESIA. Sapphire.

TELLURIUM. Mueller first suspected the existence of a new metal in the aurum paradoxicum or problematicum, which has the appearance of an ore of gold, though very little can be extracted from it. Klaproth afterward established its existence, not only is this but in some other Transylvanian ores, and named it *tellurium.*

Pure tellurium is of a tin-white colour, verging to lead-gray, with a high metallic lustre; of a foliated fracture; and very brittle, so as to be easily pulverized. Its sp. gr. is 6.115. It melts before ignition, requiring a little higher heat than lead, and less than antimony; and, according to Gmelin, is as volatile as arsenic. When cooled without agitation, its surface has a crystallized appearance. Before the blowpipe on charcoal it burns with a vivid blue light, greenish on the edges; and is dissipated in grayish-white vapours, of a pungent smell, which condense into a white oxide. This oxide heated on charcoal is reduced with a kind of explosion, and soon again volatilized. Heated in a glass retort it fuses into a straw-coloured striated mass. It appears to contain about 16 per cent. of oxygen.

Tellurium is oxidized and dissolved by the principal acids. To sulphuric acid it gives a deep purple colour. Water separates it in black flocculi, and heat throws it down in a white precipitate.

With nitric acid it forms a colourless solution, which remains so when diluted, and affords slender dendritic crystals by evaporation.

The muriatic acid, with a small portion of nitric, forms a transparent solution, from which water throws down a white submuriate. This may be redissolved almost wholly by repeated affusions of water. Alcohol likewise precipitates it.

Sulphuric acid, diluted with two or three parts of water, to which a little nitric acid has been added, dissolves a large portion of the metal, and the solution is not decomposed by water.

The alkalis throw down from its solutions a white precipitate, which is soluble in all the acids, and by an excess of the alkalis or their carbonates. They are not precipitated by prussiate of potash. Tincture of galls gives a yellow flocculent precipitate with them. Tellurium is precipitated from them in a metallic state by zinc, iron, tin, and antimony.

Tellurium fused with an equal weight of sulphur, in a gentle heat, forms a lead-coloured striated sulphuret. Alkaline sulphurets precipitate it from its solutions of a brown or black colour. In this precipitate either the metal or its oxide is combined with sulphur. Each of these sulphurets burns with a pale blue flame, and white smoke. Heated in a retort, part of the sulphur is sublimed, carrying up a little of the metal with it. It does not easily amalgamate with quicksilver.

TELLURETTED HYDROGEN. Tellurium and hydrogen combine to form a gas, called *telluretted hydrogen*. To make this compound, hydrate of potash and oxide of tellurium are ignited with charcoal, and the mixture acted on by dilute sulphuric acid, in a retort connected with a mercurial pneumatic apparatus. An elastic fluid is generated, consisting of hydrogen holding tellurium in solution. It is possessed of very singular properties. It is soluble in water, and forms a claret-coloured solution. It combines with the alkalis. It burns with a bluish flame, depositing oxide of tellurium. Its smell is very strong and peculiar, not unlike that of sulphuretted hydrogen. This elastic fluid was discovered by Sir H. Davy in 1809. When tellurium is made the electrical negative surface in water in the voltaic circuit, a brown powder is formed, which appears to be a solid combination of hydrogen and tellurium. It was first observed by Mr. Ritter in 1808. The composition of the gas and the solid hydruret has not been ascertained. The prime equivalent of tellurium, according to Sir H. Davy, is 4·93, reduced to the oxygen radix. Berzelius makes the oxide of tellurium a compound of metal 100 + oxygen 24.8. If we call the oxygen 25, then the atom or prime would be 4. In this case telluretted hydrogen, if analogous in its constitution to sulphuretted hydrogen, would have a sp. gr. of 2·2916, (not 2·3074, as Dr. Thomson deduces it from the same *data*).

TEMPERATURE. A definite degree of sensible heat, as measured by the thermometer. Thus we say a high temperature, and a low temperature, to denote a manifest intensity of heat or cold; the temperature of boiling water, or 212° Fahr.; and a range of temperature, to designate the intermediate points of heat between two distant terms of thermometric indication. According to M. Biot, *temperatures* are the different energies of caloric, in different circumstances.

The general doctrines of caloric have been already fully treated of under the articles *Caloric*, *Combustion*, *Congelation*, *Climate*, and *Pyrometer*.

The changes induced on matter, at different temperatures, relate either to its magnitude, form, or composition. The first two of these effects are considered under *Expansion*, *Concreting Temperatures*, and *Pyrometer*; the third under *Combustion*, and the *Individual Chemical Bodies*. I shall here introduce some facts concerning the temperature of living bodies, and that of our northern climates, as modified by the constitution of water.

The power which man possesses of resisting the impression of external cold is well known, and fully exemplified in high latitudes. That of sustaining high heats has been made the subject of experiment. On the Continent, the girls who are sent into ovens often endure for a short period a heat of 300° F. and upwards. If the skin be covered with varnish, which obstructs the perspiration, such heats, however, become intolerable. Dr. Fordyce staid for a considerable time, and without great inconvenience, in a room heated by stoves to 260° of Fahrenheit's scale. The lock of the door, his watch and keys, lying on the table, could not be touched without burning his hand. An egg became hard; and though his pulse beat 139 times per minute, yet a thermometer held in his mouth was only 2° or 3° hotter than ordinary. He perspired most profusely.—*Phil. Trans.* vol. 64, and 65.

It has been shown under *Caloric*, that fresh water possesses a maximum density about 39½° F. When its temperature deviates from this point, either upwards or downwards, its density diminishes, or its volume enlarges. Hence, when the intensely cold air from the circum-polar regions presses southwards, after the autumnal equinox, it progressively abstracts the heat from the great natural basins of water or lakes, till the temperature of the whole aqueous mass sinks to 39½°. At this term the refrigerating influence of the atmosphere incumbent on the water becomes nearly null. For, as the superficial stratum, by farther cooling, becomes specifically lighter, it remains on the surface, and soon becomes a cake of ice, which being an imperfect conductor of heat, screens the subjacent liquid water from the cold air. Had water resembled mercury, oils, and other liquids, in continuing to contract in volume, by cooling, till its congelation commenced, then the incumbent cold air would have robbed the mass of water in a lake of its caloric of fluidity, by unceasing precipitation of the cold particles to the bottom, till the whole sunk to 32°. Then the water at the bottom, as well as that above, would have begun to solidify, and in the course of a severe winter in these latitudes, a deep lake would have become throughout a body of ice, never again to be liquefied. We can easily see, that such frozen masses would have acted as centres of baleful refrigeration to the surrounding country; and that under such a disposition of things, Great Britain must have been another Lapland. Nothing illustrates more strikingly the beneficent economy of Providence, than this peculiarity in the constitution of water, or anomaly, as it has been rather preposterously termed. What seems void of law to unenlightened man, is often, as in the present case, found to be the finest symmetry, and truest order.

TENACITY. See Cohesion.

TENSION OF VAPOURS. See Vapour.

TENNANTITE. Colour, from lead-gray to iron-black. Massive, but usually crystallized, in rhomboidal dodecahedrons, cubes, or octohedrons. Splendent, and tin-white; occasionally dull. Cleavage dodecahedral. Streak reddish-gray. Rather harder than gray copper. Brittle. Sp. gr. 4·375. It yields a blue flame, followed by arsenical vapours; and leaves a magnetical scoria. Its constituents are, copper 45·32, sulphur 28·74, arsenic 11·84, iron 9·26, silica 5.—*Richard Phillips.* It occurs in Cornwall in copper veins that intersect granite, and clay-slate, associated with common copper pyrites. It is a variety of gray copper.

TERRA PONDEROSA. See Heavy Spar and Barytes.

TERRA JAPONICA. Catechu.

TERRA LEMNIA. A red bolar earth formerly esteemed in medicine. See Lemnian Earth.

TERRA SIENNA. A brown bole, or ochre, with an orange cast, brought from Sienna in Italy, and used in painting, both raw and burnt. When burnt, it becomes of a darker brown. It resists the fire a long time without fusing. It adheres to the tongue very forcibly.

TERRE VERTE. This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites.

TEST. In chemistry, any reagent, which, added to a substance, teaches us to distinguish its chemical nature or composition.

THALLITE. Epidote or pistacite.

THERMO-ELECTRO-MAGNETISM. M. Seebeck discovered that an electrical current can be established in a circuit formed exclusively of solid conductors, by disturbing merely the equilibrium of temperature. These constitute the subject called by the above denomination. MM. Fourier and Oersted endeavoured to ascertain whether the thermo-electric effects may be increased by the alternate repetition of bars of different materials. Their first apparatus was composed of three bars of bismuth and three of antimony, soldered alternately together, so as to form a hexagon, constituting a thermo-electric circuit, which includes three elements, or three pairs. The length of the bars was about 4·7 inches; their breadth 0·6 of an inch, and their thickness 0·16 of an inch. This circuit was put upon two supports, and in a horizontal position, observing to give to one of the sides of the hexagon the direction of the magnetic needle. A compass needle was then placed below this side, and as near it as possible. On heating one of the *solderings* with the flame of a lamp, they produced a very sensible effect on the needle. On heating two solderings not contiguous, the deviation became considerably greater; and on heating the three alternate ones a still greater effect was produced. He likewise made use of an inverse process, that is to say, they reduced to 32° F. by melting ice, the temperature of one or more solderings of the circuit. In this case the solderings not cooled must be regarded as heated in reference to the others. By combining the action of the ice with that of the flame, viz. by heating three solderings, and cooling the other three, the deviation of the needle amounted to 60°. *Ann. de Chim. et Phys.* xxii. 375, or *Journal of Science*, xvi. 126.

THERMOMETER. An instrument for measuring heat, founded on the principle, that the expansions of matter are proportional to the augmentations of temperature. With regard to aëriform bodies, this principle is probably well founded; and, hence, our common thermometers may be rendered just, by reducing their indications to those of an air thermometer. Solids, and still more liquids, expand unequally, by equal increments of heat, or intervals of temperature. With regard to water, alcohol, and oils, this inequality is so considerable as to occasion their rejection, for purposes of exact thermometry. But we have shown that mercury approaches more to solids than ordinary liquids, in its rate of expansion, and hence, as well as from its remaining liquid through a long range of temperature, it is justly preferred to the above substances for thermometric purposes. A common thermometer, therefore, is merely a vessel in which very minute expansions of mercury may be rendered perceptible; and, by certain rules of graduation, be compared with expansions made on the same liquid, by other observers. The first condition is fulfilled, by connecting a narrow glass tube with a bulb of considerable capacity, filled with quicksilver. As this fluid metal expands 1-63d by being heated in glass vessels, from the melting point of ice to the boiling point of water, if 10 inches of the tube have a capacity equal to 1-63d of that of the bulb, it is evident that, should the liquid stand at the beginning of the tube at 32°, it will rise up and occupy 10 inches of it at 212°. Hence, if the tube be uniform in its calibre, and the above space be divided into equal parts, by an attached scale, then we shall have a centigrade or Fahrenheit's thermometer, according as the divisions are

100 or 180 in number. Such are the general principles of thermometric construction. But to make an exact instrument, more minute investigation is required.

The tubes drawn at glass-houses for making thermometers are all more or less irregular in the bore, and for the most part conical. Hence, if equal apparent expansions of the included mercury be taken to represent equal thermometric intervals, these equal expansions will occupy unequal spaces in an irregular tube. The attached scale should therefore correspond exactly to these tubular inequalities; or if the scale be uniform in its divisions, we must be certain that the tube is absolutely uniform in its calibre. I may join the authority of Mr. Troughton's opinion to my own, for affirming, that a tube of a truly equable bore is seldom or never to be met with. Hence we should never construct our thermometers on that supposition.

The first step in the formation of this instrument, therefore, is to graduate the tube into spaces of equal capacity. A small caoutchouc bag, with a stop-cock and nozzle capable of admitting the end of the glass tube, when it is wrapped round with a few folds of tissue paper, must be provided; as also pure mercury, and a sensible balance. Having expelled a little air from the bag, we dip the end of the attached glass tube into the mercury, and by the elastic expansion of the caoutchouc, we cause a small portion of the liquid to rise into the bore. We then shut the stop-cock, place the tube in a horizontal direction, and remove it from the bag. The column of mercury should not exceed half an inch in length. By gently inclining the tube, and tapping it with our finger, we bring the mercury to about a couple of inches from the end where we mean to make the bulb, and, with a file or diamond, mark there the initial line of the scale. The slip of ivory, brass, or paper, destined to receive the graduations, being laid on a table, we apply the tube to it, so that the bottom of the column of mercury coincides with its lower edge. With a fine point, we then mark on the scale the other extremity of the mercurial column. Inclining the tube gently, and tapping it, we cause the liquid to flow along till its lower end is placed where the upper previously stood. We apply the tube to the scale, taking care to make its initial line correspond to the edge as before. A new point for measuring equal capacity is now obtained. We thus proceed till the requisite length be graduated; and we then weigh the mercury with minute precision.

The bulb is next formed at the enameller's blowpipe in the usual way. One of a cylindrical or conical shape is preferable to a sphere, both for strength and sensibility. We now ascertain, and note down its weight. A tubular coil of paper is to be tied to the mouth of the tube, rising in a funnel-form an inch or two above it. Into this we pour recently boiled mercury; and applying the gentle heat of a lamp to the bulb, we expel a portion of the air. On allowing the bulb to cool, a portion of the mercury will descend into it, corresponding to the quantity of air previously expelled. The bulb is now to be heated over the lamp till the included mercury boil briskly for some time. On removing it, the quicksilver will descend from the paper funnel, and completely fill the bulb and stem. Should any vesicle of air appear, the process of heating or boiling must be repeated, with the precaution of keeping a column of superincumbent mercury in the paper funnel. When the temperature of the bulb has sunk to nearly that of boiling water, it may be immersed in melting ice. The funnel and its mercury are then to be removed, and the bulb is to be plunged into boiling water. About 1-63d of the included mercury will now be expelled. On cooling the instrument again in melting ice, the zero point of the centigrade scale, corresponding to 32° of Fahrenheit, will be indicated by the top of the mercurial column. This point must be noted with a scratch on the glass, or else by a mark on the prepared scale. We then weigh the whole.

We have now sufficient data for completing the graduation of the instrument from our fixed point; and in hot climates, and other situations, where ice, for example, cannot be conveniently procured, this facility of forming an exact thermometer is important. We know the weight of the whole included mercury, and that of each *gradus* of the stem. And as from 32° to 212° F. or from 0° to 100° cent. corresponds to a mercurial expansion in glass of 1-63d, we can easily compute how many of our graduating spaces are contained in the range of temperature, between freezing and boiling water. Thus, supposing the mercurial contents to be 378 grains, 1-63d of that quantity, or 6 grains, correspond to 180 of Fahrenheit's degrees. Now, if the initial measuring column were 0·6 of a grain, then 10 of these spaces would comprehend the range between freezing and boiling water. Hence, if we know the boiling point, we can set off the freezing point; or, from the temperature of the living body, 98° F., we can set off both the freezing and boiling points of water. In the present case, we must divide each space on our prepared scale into 18 equal parts, which would constitute degrees of Fahrenheit; or into 10 equal parts, which would constitute centigrade degrees; or into 8, which would form Reaumur's degrees. I have graduated thermometers in this way, and have found them to be very correct. When we have ice and boiling water at our command, however, we may dispense with the weighing processes. By plunging the instrument into melting ice, and then into boiling water, we find how many of our initial spaces on the stem correspond to that interval of temperature, and we subdivide them accordingly. If the tube be very unequable, we must accommodate even our subdivisions to its irregularities, for which purpose the eye is a sufficient guide.

Thermometers are used for two different purposes, each of which requires peculiar adaptation. Those employed in meteorology, or for indicating atmospherical temperature, are wholly plunged in the fluid, and hence the stem as well as bulb are equally affected by the calorific energy. But when the chemist wishes to ascertain the temperature of corrosive liquids, or bland liquids highly heated, he can immerse merely the bulb, and the naked part of the stem under the scale. The portion of the tube corresponding to the scale is not influenced by the heat, as in the former case; and hence, 1-63d part of the mercury, which at 32° F. was acted on, has at 212° escaped from its influence. (MM. Dulong and Petit make it 1-64·8th between 32° and 212°; see CALORIC). Hence I conceive, that a meteorological and a chemical thermometer ought to be graduated under the peculiar conditions in which they are afterwards to be used. The former should have its stem surrounded with the steam of boiling water, while its bulb is immersed an inch or two beneath the surface of that liquid, the barometer having at the time an altitude of 30 inches.

For ascertaining the boiling point on a thermometer stem, I adapt to the mouth of a tea-kettle a cylinder of tin-plate, the top of which contains a perforated cork. Through this the glass tube can be slid to any convenient point; while the tin cylinder may also be raised or lowered, till the bulb rest an inch beneath the water. The nozzle of the kettle is shut with a cork; and at the top of the cylinder, a side-hole for escape of the steam is left. If the barometer differs from 30 by one inch, then the boiling point of water will differ by 1·92° F. Or 1° F. by Mr. Wollaston, corresponds to a difference of 0·589 of barometric pressure. When the barometer, for example, stands at 29 inches, water boils at 210·08 F.; and when it stands at 31 inches, the boiling temperature is 213·92. Particular attention must be paid to this source of variation.

A thermometer for chemical experiment should have its boiling point determined, by immersion only of the bulb and the naked portion of its stem below the scale, in boiling water. It is surely needless to say, that the water ought to be pure, since the presence of saline matter affects its boiling temperature; and it ought to be contained in a metallic vessel.

Before sealing up the end of the tube, we should draw it into a capillary point, and heat the bulb till the mercury occupy the whole of the stem. A touch of the blowpipe flame on the capillary glass will instantly close it, and exclude the air from re-entering when the bulb becomes cool. If this has been skilfully executed, the column of mercury will move rapidly from one end of the tube to the other, when it is inverted with a jerk. An ivory scale is the handsomest, but the most expensive. Those used in Paris consist of a narrow slip of paper, enclosed in a glass tube, which is attached in a parallel direction to the thermometer stem. It is soldered to it above, by the lamp, and hooked to it below, by a ring of glass. Such instruments are very convenient for corrosive liquids; and I find them not difficult to construct.

In treating of the measure of temperature under CALORIC, I have endeavoured to show, that were the whole body of the thermometer, stem and bulb, immersed in boiling mercury, it would indicate 35° more than it does on the supposition of the bulb alone being subjected to the calorific influence, as takes place in common experiments. But MM. Dulong and Petit state, that it ought to indicate 680° in the former case, while Mr. Crichton shows that it actually indicates 656° in the latter, giving a difference of only 24° instead of 35°. This discordance between fact and theory is only apparent; for we must recollect that mercury being an excellent conductor of heat, will communicate a portion of that expansive energy from the immersed bulb, to the mercury in the stem, which will be retained, in consequence of glass being a very imperfect conductor of heat. Hence we may infer, that but for this communication of heat to the stem, a thermometer, whose bulb alone is plunged in boiling mercury, would stand at 645° F., or 17° below the true boiling temperature by an air thermometer, according to MM. Dulong and Petit. If we take the mean apparent expansion of mercury, in glass, for 180°, between 32° and 662°, as given by these chemists at 1-64th; then the above reduction would become 34·4° instead of 35°, an inconsiderable difference.

In consequence of this double compensation, a good mercurial thermometer, as constructed by Crichton, becomes an almost exact measure of temperature, or of the relative apparent energies of caloric.

At the end of the Dictionary a table of reduction is given for the three thermometric scales at present used in Europe; that of Reaumur, Celsius or the centigrade, and Fahrenheit. The process of reduction is however a very simple case of arithmetic. To convert the centigrade interval into the Fahrenheit, we multiply by 1·8 or by 6 and 0·3, marking off the last figure of the product as a decimal. Thus an interval of 17° centigrade =17° × 6 × 0·3=one of 30·6° Fahrenheit. But as the former scale marks the melting of ice 0°, and the latter 32°, we must add 32°

o have the Fahrenheit number =

r form of the same rule of conversion
uble the centigrade interval subtract
the remainder is the Fahrenheit
Thus, from the double of 17°=34°,
7 = 3·4, the remainder 30·6 is the
ling interval on Fahrenheit's scale.
t the Fahrenheit intervals into the
, divide by 6 and by 0·3, and mark
imal point thus: $95° F. = \frac{95°}{6\times0{\cdot}3} =$

we wish to reduce a Fahrenheit
o a centigrade, we must begin by
the 32° which the former is in
ver the latter, at the melting of ice,
the French scale. Thus to convert
the centigrade scale; 95° — 32° =
$\frac{\;}{\cdot3} = 35°$ C.

ed in arithmetical reduction know
tageous it is to confine it if possible
e, and not to blend two or more.
ordinary rule of multiplying by 9,
ng by 5, to bring the Fahrenheit to
ade intervals, seems less convenient
preceding. With regard to the
scale, however, which is now of rare
, we may employ the usual proportion
or to the double add one-fourth:
F. =9-4ths R. and
R. =4-9ths F.
the relations of the intervals.
t, however, attend to the initial 32°
eit.

$$= \frac{F° - 32°}{6\times0{\cdot}3}$$

$$= (C° \times 6 \times 0{\cdot}3) + 32°$$

$$= \frac{4(F - 32°)}{9}$$

$$\tfrac{9}{4}R + 32°$$

$$\frac{R°}{0{\cdot}8}$$

$$0{\cdot}8 \times C°.$$

h volume of the Phil. Magazine,
of Glasgow has described a self-
ermometer of his invention, con-
oblong slips of steel and zinc,
ogether by their faces; so that
xpansion or contraction of the
se of the steel, by the same
emperature causes a flexure of
bar. As this is secured to a
d, the whole flexure is exercised
the short arm of a lever index,
mity of which moves along a
The instrument is originally
good mercurial thermometer;
nts of the arm are registered by
which are pushed before it,
maximum deviation to the
the last observed position or

temperature. The principle is obviously that of Arnold's compensation balance for chronometers.

An exquisite instrument on the same principle has been invented by M. Breguet, member of the Academy of Sciences, and Board of Longitude of France. It consists of a narrow metallic slip, about $\frac{1}{100}$ of an inch thick, composed of silver and platina, soldered together; and it is coiled in a cylindrical form. The top of this spiral tube is suspended by a brass arm, and the bottom carries, in a horizontal position, a very delicate golden needle, which traverses as an index on a graduated circular plate. A steel stud rises in the centre of the tube, to prevent its oscillations from the central position. If the silver be on the outside of the spiral, then the influence of increased temperature will increase the curvature, and move the appended needle in the direction of the coil; while the action of cold will relax the coil, and move the needle in the opposite direction. M. Breguet was so good as to present me with two instruments; both of which are perfect thermometers, but one is the most sensible which I ever saw. For some details concerning it, see Caloric. Dr. Wollaston showed me in 1809 a slip of copper coated with platinum, which exhibited by its curvature over flame or the vapour of water, the expanding influence of heat, in a striking manner. For other facts concerning the measurement of heat, see Caloric.

THOMSONITE. A mineral of the zeolite family, found in the neighbourhood of Kilpatrick near Dumbarton. The primary form of its crystals is a right rectangular prism.

THORINA. A supposed new earth, described as such in 1816 by M. Berzelius. He has since found it to be merely a subphosphate of yttria.

THULITE. A hard peach-blossom coloured mineral found at Sonland, in Tellemark in Norway.

THUMERSTONE. Axinite.

TILE ORE. A sub-species of octohedral red copper ore.

TIN is a metal of a yellowish-white colour, considerably harder than lead, scarcely at all sonorous, very malleable, though not very tenacious. Under the hammer it is extended into leaves, called tin-foil, which are about one-thousandth of an inch thick, and might easily be beaten to less than half that thickness, if the purposes of trade required it. The process for making tin-foil consists simply in hammering out a number of plates of this metal, laid together upon a smooth block or plate of iron. The smallest sheets are the thinnest. Its specific gravity is 7·29. It melts at about the 442° of Fahrenheit's thermometer; and by a continuance of the heat it is slowly converted into a white powder by oxidation. Like lead, it is brittle when heated almost to fusion, and exhibits a grained or fibrous texture, if broken by the blow of a hammer; it may also be granulated by agitation at the time of its transition from the fluid to the solid state. The oxide of tin resists fusion more strongly than that of any other metal; from which property it is useful to form an opaque white enamel when mixed with pure glass in fusion. The brightness of its surface, when scraped, soon goes off by exposure to the air; but it is not subject to rust or corrosion by exposure to the weather.

To obtain pure tin, the metal should be boiled in nitric acid, and the oxide which falls down reduced by heat in contact with charcoal, in a covered crucible.

There are two definite combinations of tin and oxygen. The first or protoxide is gray; the second or peroxide is white. The first is formed by heating tin in the air, or by dissolving tin in muriatic acid, and adding water of potash to the solution whilst recent, and before it has been exposed to air. The precipitate, after being heated to whiteness to expel the water of the hydrate, is the pure protoxide. It is convertible into the peroxide by being boiled with dilute nitric acid, dried and ignited. According to Sir H. Davy, the protoxide contains 13.5 per cent. of oxygen. Supposing it to consist of a prime equivalent of each constituent, that of tin would be 7·333. From the analyses of Berzelius and Gay Lussac, the peroxide is composed of 100 metal + 27.2 oxygen; and if we regard it as containing two primes of the latter principle to 1 of metal, the prime of this will be 7.353. The mean may be taken at 7.35.

There are also two *chlorides* of tin. When tin is burned in chlorine, a very volatile clear liquor is formed, a non-conductor of electricity, and which, when mixed with a little water, becomes a solid crystalline substance, a true muriate of tin, containing the peroxide of the metal. This, which has been called the liquor of Libavius, may be also procured, by heating together tin-filings and corrosive sublimate, or an amalgam of tin and corrosive sublimate. It consists, according to the analysis of Dr. John Davy, of 2 primes of chlorine = 9 + 1 of tin = 7·35. The other compound of tin and chlorine is a gray semitransparent crystalline solid. It may be procured by heating together an amalgam of tin and calomel. It dissolves in water, and forms a solution, which rapidly absorbs oxygen from the air, with deposition of peroxide of tin. It consists of,

Chlorine, 4·5
Tin, 7·35

There are two sulphurets of tin. One may be made by fusing tin and sulphur together. It is of a bluish colour, and lamellated texture. It consists of 7·35 tin + 2 sulphur. The other sulphuret, or the bisulphuret, is made by heating together the peroxide of tin and sulphur. It is of a beautiful gold colour, and appears in fine flakes. It was formerly called *aurum musivum*. According to Dr. John Davy, it consists of 1 prime tin = 7·35
2 sulphur = 4·00
For another mode of making it, see AURUM MUSIVUM.

The salts of tin are characterized by the following general properties:—

1. Ferroprussiate of potash gives a white precipitate.

2. Hydrosulphuret of potash, a brown-black with the protoxide; and a golden-yellow with the peroxide.

3. Galls do not affect the solutions of these salts.

4. Corrosive sublimate occasions a black precipitate with the protoxide salts; a white with the peroxide.

5. A plate of lead frequently throws down metallic tin, or its oxide, from the saline solutions.

6. Muriate of gold gives, with the protoxide solutions, the purple precipitate of Cassius.

7. Muriate of platinum occasions an orange precipitate with the protoxide salts.

Concentrated sulphuric acid, assisted by heat, dissolves half its weight of tin, at the same time that sulphurous gas escapes in great plenty. By the addition of water, an oxide of tin is precipitated. Sulphuric acid, slightly diluted, likewise acts upon this metal; but if much water be present, the solution does not take place. In the sulphuric solution of tin, there is an actual formation or extrication of sulphur, which renders the fluid of a brown colour while it continues heated, but subsides by cooling. The tin is likewise precipitated in the form of a white oxide, by a continuance of the heat, or by long standing without heat. This solution affords needle-formed crystals by cooling.

Nitric acid and tin combine together very rapidly without the assistance of heat. Most of the metal falls down in the form of a white oxide, extremely difficult of reduction; and the small portion of tin which remains suspended, does not afford crystals, but falls down, for the most part, upon the application of heat to inspissate the fluid. The strong action of the nitric acid upon tin produces a singular phenomenon, which is happily accounted for by the modern discoveries in chemistry. M. de Morveau has observed, that, in a solution of tin by the nitric acid, no elastic fluid is disengaged, but ammonia is formed. This alkali must have been produced by the nitrogen of that part of the nitric acid which was employed in affording oxygen to oxidize the tin.

The muriatic acid dissolves tin very readily, at the same time that it becomes of a darker colour, and ceases to emit fumes. A slight effervescence takes place with the disengagement of a fetid inflammable gas. Muriatic not let it fall by repose. It should permanent crystals by evaporation. If the tin contain arsenic, it remains undissolved at the bottom of the fluid. Recent muriate of tin is a very delicate test of mercury. M. Chenevix says, if a single drop of a saturated solution of neutralized nitrate, or muriate of mercury, be put into 500 grains of water, a few drops of solution of muriate of tin will render it a little turbid, and of a smoke-gray. He adds, that the effect is perceptible, if ten times as much water be added.

Aqua regia, consisting of two parts nitric and one muriatic acid, combines with tin with effervescence, and the development of much heat. In order to obtain a permanent solution of tin in this acid, it is necessary to add the metal by small portions at a time; so that the one portion may be entirely dissolved before the next piece is added. Aqua regia, in this manner, dissolves half its weight of tin. The solution is of a reddish-brown, and in many instances assumes the form of a concrete gelatinous substance. The addition of water sometimes produces the concrete form in this solution, which is then of an opal colour, on account of the oxide of tin diffused through its substance.

The uncertainty attending these experiments with the solution of tin in aqua regia, seems to depend upon the want of a sufficient degree of accuracy in ascertaining the specific gravities of the two acids which are mixed, the quantities of each, and of the tin, together with that of the water added. It is probable, that the spontaneous assumption of the concrete state depends upon water imbibed from the atmosphere. The solution of tin in aqua regia is used by dyers to heighten the colours of cochineal, lac-dye, and some other red tinctures, from crimson to a bright scarlet, in the dyeing of woollens.

The acetic acid scarcely acts upon tin. The operation of other acids upon this metal has been little inquired into. Phosphate, fluate, and borate of tin, have been formed by precipitating the muriate with the respective neutral salts.

If the crystals of the saline combination of copper with the nitric acid be grossly powdered, moistened, and rolled up in tinfoil, the salt deliquesces, nitrous fumes are emitted, the mass becomes hot, and suddenly takes fire. In this experiment, the rapid transition of the nitric acid to the tin is supposed to produce or develope heat enough to set fire to the nitric salts; but by what particular changes of capacity, has not been shown.

If small pieces of phosphorus be thrown on tin in fusion, it will take up from 15 to 20 per cent. and form a silvery white phosphuret of a foliated texture, and soft enough to be cut with a knife, though but little malleable. This phosphuret may be formed likewise by

acid.

Tin unites with bismuth by fusion, and becomes harder and more brittle in proportion to the quantity of that metal added. With nickel it forms a white brilliant mass. It cannot easily be united in the direct way with arsenic, on account of the volatility of this metal; but by heating it with the combination of the arsenical acid and potash, the salt is partly decomposed; and the tin combining with the acid, becomes converted into a brilliant brittle compound, of a plaited texture. It has been said, that all tin contains arsenic; and that the crackling noise which is heard upon bending pieces of tin, is produced by this impurity; but, from the experiment of Bayen, this appears not to be the fact. Cobalt unites with tin by fusion; and forms a grained mixture of a colour slightly inclining to violet. Zinc unites very well with tin, increasing its hardness, and diminishing its ductility, in proportion as the quantity of zinc is greater.

This is one of the principal additions used in making pewter, which consists for the most part of tin. The best pewter does not contain above one-twentieth part of admixture, which consists of zinc, copper, bismuth, or such other metallic substances as experience has shown to be most conducive to the improvement of its hardness and colour. The inferior sorts of pewter, more especially those used abroad, contain much lead, have a bluish colour, and are soft. The tin usually met with in commerce in this country, has no admixture to impair its purity, except such as may accidentally elude the workmen at the mines. But the tin met with in foreign countries is so much debased by the dealers in that article, especially the Dutch, that pewter and tin are considered abroad as the same substance.

Antimony forms a very brittle hard mixture with tin; the specific gravity of which is less than would have been deduced by computation from the specific gravities and quantities of each, separately taken. Tungsten fused with twice its weight of tin, affords a brown spongy mass, which is somewhat ductile.

The uses of tin are very numerous, and so well known, that they scarcely need be pointed out. Several of them have been already mentioned. The tinning of iron and copper, the silvering of looking-glasses, and the fabrication of a great variety of vessels and utensils for domestic and other uses, are among the advantages derived from this metal.

TINCAL. Crude borax, as it is imported from the East Indies, in yellow greasy crystals, is called tincal.

TINGLASS. Bismuth.

TINNING. See Iron.

TITANIFEROUS CERITE. A mineral from the Coromandel coast, of a blackish-brown colour, a vitreous conchoidal fracture, hardness equal to that of the gadolinite, and swelling up when heated. Both alkalis and acids act upon it. Its constituents are, oxide of cerium 36, oxide of iron 19, lime 8, alumina 6, water 11, oxide of manganese 1·8, silica 19, oxide of titanium 8. These quantities exceed 100 by 9.55 parts, an excess occasioned by the protoxide of cerium in the mineral becoming peroxide in the analysis.—*Laugier. Annales de Chim. et Phys.* xxvii. 313.

TITANITES. This name has been given to certain ores of titanium, containing that metal in the state of oxide. See the following article.

TITANIUM. The Rev. Mr. Gregor discovered in a kind of ferruginous sand, found in the vale of Menachan, in Cornwall, what he supposed to be the oxide of a new metal, but was unable to reduce.

Klaproth, afterward analyzing what was called the red schorl of Hungary, found it to be the pure oxide of a new metal, which he named titanium, and the same with the menachanite of Mr. Gregor. Since that, oxide of titanium has been discovered in several fossils.

We do not know that titanium has been completely reduced, except by Lampadius, who effected it by means of charcoal only. The oxide he employed was obtained from the decomposition of gallate of titanium by fixed alkali. The metal was of a dark copper colour, with much metallic brilliancy, brittle, and in small scales considerably elastic. It tarnishes in the air, and is easily oxidized by heat. It then acquires a bluish aspect. It detonates with nitre, and is highly infusible. All the dense acids act upon it with considerable energy. According to Vauquelin, it is volatilized by intense heat.

Certain small cubes occasionally observed in iron slag, had generally been regarded as pyritical, but upon minute inspection, Dr. Wollaston observed, that neither their colour, crystallization, nor hardness, were those of pyrites. The crystals are striated. Purified from iron by muriatic acid, they are insoluble in muriatic, nitric, nitro-muriatic, and sulphuric acids. Their perfect solution may be effected by the combined action of nitre and borax, since the latter dissolves the oxide as fast as it is formed, and presents a succession of clear surfaces for fresh oxidation. But as these salts do not unite by fusion, the addition of soda, as a medium of union, shortens the process. The fused mass becomes opaque on cooling by the deposition of a white oxide, which may either be previously freed of the salts by boiling water, and then dissolved in muriatic acid, or the whole mass may be at once dissolved together. In either case, alkalis precipitate from the solution a white oxide, which is not soluble by excess of alkali either pure or carbonated. By evaporating the muriatic solution of the oxide to dryness, at the heat of boiling water, it is freed of any redundant acid, and the muriate which remains is perfectly soluble in water, and in a state most favourable for exhibiting the characteristic properties of the metal. Infusion of galls gives the well-known red colour of gallate of titanium. The colour occasioned by prussiate of potash is also red, differing from prussiate of copper, by inclining to orange instead of purple, while the colour of prussiate of uranium is rather brown than red.

The above crystals are perfect conductors of electricity. Titanium shows no affinity for iron; and it seems equally indisposed to unite with every other metal that Dr. Wollaston tried. The specific gravity of the metallic titanium is 5·3; and it is so hard as to scratch agate. *Dr. Wollaston, in Phil. Trans. for* 1823.

M. Rose obtained oxide of titanium by fusing powdered rutilite with thrice its weight of carbonate of potash, dissolving the compound in muriatic acid, precipitating by caustic ammonia, digesting the precipitate for a certain time with hydrosulphuret of ammonia, and finally digesting the solid matter left in weak muriatic acid, which leaves the oxide of titanium pure. In this way only, as yet, can the iron be removed. The pure oxide remains perfectly white when heated and cooled, and is then untouched by acids. Fused with carbonate of potash, and then treated with muriatic acid, it sometimes gelatinizes, though not so strongly as silica. It becomes red by touching moist litmus, and with alkalis acts precisely as an acid. It has therefore been called by M. Rose titanic acid. There are no salts with base of titanic acid; those that have been taken for such, resulted from the presence of alkali in the titanic acid. See ACID (TITANIC).

The native red oxide is insoluble in the sulphuric, nitric, muriatic, and nitro-muriatic acids: but if it be fused with six parts of carbonate of potash, the oxide is dissolved with effervescence. The sulphuric solution when evaporated becomes gelatinous; the nitric affords rhomboidal crystals by spontaneous evaporation, but is rendered turbid by ebullition; the muriatic becomes gelatinous, or flocculent, by heat, and transparent crystals form in it when cooled; but if it be boiled, oxygenized muriatic acid gas is evolved, and a white oxide thrown down. Phosphoric and arsenic acids take it from the others, and form with it a white precipitate. These precipitates are soluble in muriatic acid, but in no other.

The solutions of titanium give white precipitates with the alkalis, or their carbonates; tincture of galls gives a brownish-red, and prussiate of potash a brownish yellow. If the prussiate produce a green precipitate, this, according to Lowitz, is owing to the presence of iron. Zinc immersed in the solutions changes their colour from yellow to violet, and ultimately to an indigo; tin produces in them a pale red tint, which deepens to a bright purple red. Hydrosulphuret of potash throws down a brownish-red precipitate, but they are not decomposed by sulphuretted hydrogen.

By exposing phosphate of titanium, mixed with charcoal and borax, to a violent heat, in a double crucible luted, M. Chenevix obtained a pale white phosphuret, with some lustre, brittle, of a granular texture, and not very fusible.

The oxides of iron and titanium, exposed to heat with a little oil and charcoal, produce an alloy of a gray colour, intermixed with brilliant metallic particles of a golden yellow.

Oxide of titanium was used to give a brown or yellow colour in painting on porcelain, before its nature was known; but it was found difficult to obtain from it an uniform tint, probably from its not being in a state of purity.

TOBACCO. The expressed juice of the leaves, according to Vauquelin, contains the following substances:

A considerable quantity of vegetable albumen or gluten; supermalate of lime; acetic acid.

A notable quantity of nitrate and muriate of potash. A red matter soluble in alcohol and water, which swells considerably when heated.

Muriate of ammonia.

Nicotin.

Green fecula, composed chiefly of gluten, green resin, and woody fibre.

TOLU (BALSAM OF). This substance is obtained from the toluifera balsamum, a tree which grows in South America. The balsam flows from incisions made in the bark. It comes to Europe in small gourd shells. It is of a reddish-brown colour and considerable consistence; and when exposed to the air, it becomes solid and brittle. Its smell is fragrant, and continues so, even after the balsam has become thick by age. When distilled with water, it yields very little volatile oil, but impregnates the water strongly with its taste and smell. A quantity of benzoic acid sublimes, if the distillation be continued.

Mr. Hatchett found it soluble in the alkalis, like the rest of the balsams. When he dissolved it in the smallest possible quantity of lixivium of potash, it completely lost its own odour. and assumed a fragrant smell, somewhat resembling that of the clove-pink. "This smell," Mr. Hatchett observes, "is not fugitive, for it is still retained by a solution which was prepared in June, and has remained in an open glass during four months."

When digested in sulphuric acid, a considerable quantity of pure benzoic acid sublimes. When the solution of it in this acid is evaporated to dryness, and the residuum treated with alcohol, a portion of artificial tannin is obtained: the residual charcoal amounts to 0.54 of the original balsam.

Mr. Hatchett found, that it dissolved in nitric acid, with nearly the same phenomena as the resins; but it assumed the smell of bitter almonds, which led him to suspect the formation of prussic acid. During the solution in nitric acid, a portion of benzoic acid sublimes. By repeated digestions, it is converted into artificial tannin.

It is totally soluble in alcohol, from which water separates the whole of it, except the benzoic acid.

TOMBAC. A white alloy of copper with arsenic, commonly brittle, though if the quantity of arsenic be small, it is both ductile and malleable in a certain degree. It is sometimes called white copper.

TOPAZ. According to Professor Jameson, this mineral species contains three subspecies, common topaz, schorlite, and physalite.

Common topaz. Colour wine-yellow. In granular concretions, disseminated and crystallized. Its primitive form is an oblique prism of 124° 22′. The following are secondary forms. An oblique four-sided prism, acuminated by four planes; the same, with the acute lateral edges bevelled; the same, with a double acumination; and several other modifications, for which consult Jameson's Min. vol. i. p. 75. The lateral planes are longitudinally streaked. Splendent and vitreous. Cleavage perfect and perpendicular to the axis of the prism. Fracture, small conchoidal. Transparent. Refracts double. Harder than quartz, or emerald; but softer than corundum. Easily frangible. Sp. gr. 3·4 to 3·6.

Saxon topaz in a gentle heat becomes white, but a strong heat deprives it of lustre and transparency. The Brazilian, on the contrary, by exposure to a high temperature, burns rose-red, and in a still higher violet-blue. Before the blowpipe, it is infusible. The topaz of Brazil, Siberia, Mucla in Asia Minor, and Saxony, when heated, exhibit at one extremity positive, and at the other negative, electricity. It also becomes electrical by friction; and retains its electricity very long. Its constituents are,—

	Braz. Top.	Sax. T.	Sax. T.
Alumina,	58·38	57·45	59
Silica,	34·01	34·24	35
Fluoric acid,	7·79	7·75	5
	100·18	99·44	99
	Berzelius.	*Klapr.*	*Klapr.*

Topaz forms an essential constituent of a particular mountain-rock, which is an aggregate of topaz, quartz, and schorl, and is named topaz-rock. Topaz occurs in drusy cavities in granite. It has been also discovered in nests, in transition clay-slate; and it is found in rolled pieces in alluvial soil. It occurs in large crystals, and rolled masses, in an alluvial soil, in the granite and gneiss districts of Mar and Cairngorm, in the upper parts of Aberdeenshire; and in veins, along with tin-stone, in clay-slate at St. Anne's, Cornwall. On the continent it appears most abundantly in topaz-rock at Schneckenstein.—*Jameson.*

TOPAZOLITE. A variety of precious garnet, found at Mussa in Piedmont.

TORRELITE. A new mineral from Sussex county, New Jersey. Colour, dull vermilion red; fracture granular, fine or coarse. Scratches glass. Powder, rose-red. Affects the magnet slightly. Effervesces with acids. Forms with borax a glass that is green while hot, but colourless on cooling. Infusible alone at the blowpipe. Its constituents are,

Silica,	16·30
Perox. of cerium,	6·16
Protox. of iron,	10·50
Alumina,	1·84
Lime,	12·04
Water,	1·75
Loss,	1·41
	50·60

Mr. Children has proved, that the mineral of Dr. Torrey contains manganese, of which his analysis takes no account; and neither he nor Mr. Faraday could find any cerium in it.—*Annals of Phil.*, ix. 217.

TORTOISE-SHELL. It approaches to nail or coagulated albumen in its composition. 500 parts, after incineration, leave three of earthy matter, consisting of phosphate of lime, and soda, with a little iron.

TOUCHSTONE. Lydian stone, a variety of *flinty-slate.*

TOURMALINE. Rhomboidal tourmaline is divided into two sub-species, *schorl*, and *tourmaline.*

Tourmaline. Colours green and brown. In prismatic concretions, rolled pieces, but generally crystallized. Primitive form, a rhomboid of 133° 26′. It occurs in an equiangular three-sided prism, flatly acuminated on the extremities with three planes. The lateral edges are frequently bevelled, and thus a nine-sided prism is formed: when the edges of the bevelment are truncated, a twelve-sided prism is formed; and when the bevelling planes increase so much that the original faces of the prism disappear, an equiangular six-sided prism is formed. Sometimes the prism is nearly wanting, when a double three-sided pyramid is formed. The lateral planes are generally cylindrical convex, and deeply longitudinally streaked. Crystals embedded. Splendent, vitreous. Cleavage threefold. Fracture conchoidal. Opaque to transparent. Refracts double. When viewed perpendicular to the axis of the crystal, it is more or less transparent, but in the direction of the axis, even when the length of the prism is less than the thickness, it is opaque. As hard as quartz. Easily frangible. Sp. gr. 3·0 to 3·2. By friction it yields vitreous electricity; by heating, vitreous at one end, and resinous at the other. The brown and hyacinth-red varieties have these properties in the greatest degree. The ancients called it *lyncurium.* Before the blowpipe, it melts into a grayish-white vesicular enamel. Its constituents are, silica 42, alumina 40, soda 10, oxide of manganese with a little iron 7, loss 1.—*Vauquelin.* It occurs in gneiss, mica-slate, talc-slate, &c. The red occurs in Siberia, Ava, and Ceylon.—*Jameson.*

TRACHYTE. A rock of igneous origin, principally composed of felspar, and consequently fusible into a white or slightly coloured enamel. It has generally a porphyritic structure. See *D'Aubuisson's Géologie,* ii. 524.

TRAGACANTH (GUM). This substance, which is vulgarly called gum-dragon, exudes from a prickly bush, the *astragalus tragacantha*, Linn. which grows wild in the warmer climates, and endures the cold of our own, but does not here yield any gum. This commodity is brought chiefly from Turkey, in irregular lumps, or long vermicular pieces bent into a variety of shapes; the best sort is white, semitransparent, dry, yet somewhat soft to the touch.

Gum-tragacanth differs from all the other known gums, in giving a thick consistence to a much larger quantity of water; and in being much more difficultly soluble, or rather dissolving only imperfectly. Put into water it slowly imbibes a great quantity of the liquid, swells into a large volume, and forms a soft but not fluid mucilage; if more water be added, a fluid solution may be obtained by agitation; but the liquor looks turbid and wheyish, and on standing, the mucilage subsides, the limpid water on the surface retaining little of the gum. Nor does the admixture of the preceding more soluble gums promote its union with the water, or render its dissolution more durable: when gum-tragacanth and gum-arabic are dissolved together in water, the tragacanth seems to separate from the mixture more speedily than when dissolved by itself.

Tragacanth is usually preferred to the other gums for making up troches, and other like purposes, and is supposed likewise to be the most effectual as a medicine; but on account of its imperfect solubility, is unfit for liquid forms. It is commonly given in powder with the addition of other materials of similar intention; thus, to one part of gum-tragacanth are added one of gum-arabic, one of starch, and six of sugar. See CERASIN.

According to Bucholz, gum-tragacanth is composed of 57 parts of a matter similar to gum-arabic, and 43 parts of a peculiar substance, capable of swelling in cold water without dissolving, and assuming the appearance of a thick jelly. It is soluble in boiling water, and then forms a mucilaginous solution.

TRAP FORMATIONS in geology.

Primitive trap. The name trap is derived from the Swedish word *trappa*, a stair. Werner understands by trap, rocks principally characterized by the presence of hornblende, and black iron clay. Hence all rocks occurring in the primitive class, having hornblende as a characteristic, or predominating ingredient, belong to the *primitive trap formation.* The following table from Professor Jameson exhibits the rocks of this formation.

1. Common hornblende rock.
    a. Granular hornblende rock.
    b. Hornblende slate.
2. Hornblende mixed with felspar.
    a. Greenstone.
        α. Common greenstone.
        β. Porphyritic greenstone.
        γ. Greenstone porphyry.
        δ. Green porphyry.
    b. Greenstone slate.
3. Hornblende mixed with mica.

Transition trap. It contains greenstone and amygdaloid.

The *newest floetz-trap* contains several rocks which are peculiar to it, and others that occur in other floetz formations. The peculiar or characteristic rocks are, *basalt, wacke, graystone, porphyry-slate,* and traptuff. These, and also greenstone, are often called whinstone by mineralogists.

TRAP-TUFF. It is composed of masses of basalt, amygdaloid, hornblende rock, sandstone, and even pieces of wood (as in the island of Canna) cemented together by a rather loose spongy clayey basis, which has been formed from decomposed basalt or wacke rock. The masses vary much in size, from that of a pea, to several hundred weight. It occurs in beds, which are from a few inches to several fathoms thick. A considerable portion of Arthur's Seat, near Edinburgh, is composed of this rock: there it rests on inclined strata which belong to the oldest coal formation. It occurs also in Mull, and many other places in Scotland.

TRAUMATE. The name given by the French geologists to graywacke.

TREMOLITE. This sub-species of straight-edged augite is divided into three kinds; the asbestous, common, and glassy.

1. *Asbestous tremolite.* Colour grayish-white. Massive, and in fibrous concretions. Shining, pearly. Fragments splintery. Translucent on the edges. Rather easily frangible. Soft. Rather sectile. When struck gently, or rubbed in the dark, it emits a pale reddish light; when pounded and thrown on coals, a greenish light. Before the blowpipe, it melts into a white opaque mass. It occurs most frequently in granular foliated limestone, or in dolomite. It is found in the former in Glentilt and Glenelg; in the latter, in Aberdeenshire and Icolmkill; and in basalt in the Castle rock of Edinburgh.

2. *Common tremolite.* Colour white. Massive, in distinct prismatic concretions, and crystallized in a very oblique four-sided prism, truncated or bevelled on the lateral edges; in an extremely oblique four-sided prism, perfect or variously modified by bevelment or truncation. The lateral planes are longitudinally streaked. Vitreous or pearly. Cleavage double oblique angular, of 124° 50′ and 55° 50′. Fracture uneven or conchoidal. Translucent. As hard as hornblende. Rather brittle. Sp. gr. 2·9 to 3·2. It melts with much difficulty and ebullition into an opaque glass. Its constituents are, silica 50, magnesia 25, lime 18, carbonic acid and water 5. —*Laugier.* It occurs with the preceding.

3. *Glassy tremolite.* Colour grayish, greenish, yellowish, and reddish-white. Massive, in distinct concretions, and frequently crystallized in long acicular crystals. Shining, between vitreous and pearly. Translucent. As hard as hornblende. Very brittle. Sp. gr. 2·863. It is phosphurescent in a low degree. Infusible. Its constituents are, silica 35·5, lime 26·5, magnesia 16·5, water and carbonic acid 23.—*Laugier.* It occurs with the preceding.—*Jameson.*

TRIPHANE. See SPODUMENE.

TRIPOLI. Colour yellowish-gray. Massive. Fracture fine or coarse earthy. Opaque. Soft. Rather easily frangible. Meagre. Does not adhere to the tongue. Sp. gr. 2·2. Infusible. Its constituents are, silica 81, alumina 1·5, oxide of iron 8, sulphuric acid 3·45, water 4·55.—*Bucholz.* Of the *rottenstone,* silica 4, alumina 86, carbon 10.—*Phillips.* It occurs in beds in coal-fields, with secondary limestone, and under basalt. It is found at Bakewell, in Derbyshire, where it is called *rottenstone.* It is used for polishing stones, metals, and glasses. The *tripoli* of Corfu is reckoned the most valuable.

TRONA. The name given in Africa to the native carbonate of soda, found at Sukena, near Fezzan.

TUBE OF SAFETY. A tube open at both ends, inserted into a receiver, the upper end communicating with the external air, and the lower being immersed in water. Its intention is to prevent injury from too sudden condensation or rarefaction taking place during an operation. For, if a vacuum be produced within the vessels, the external air will enter through the tube: and if air be generated, the water will yield to the pressure, being forced up the tube. Thus, too, the height of the water in the tube indicates the degree of pressure from the confined gas or gases. See Pl. VII. fig. 3. *h.* It is now more frequently used in a curved form, ib. fig. 1.; and is commonly called a Welter's tube.

TUFACEOUS LIMESTONE, or CALC TUFF. See LIMESTONE.

TUMITE. See THUMMERSTONE.

TUNGSTEN. See ORES OF TUNGSTEN.

TUNGSTENUM. This name, signifying heavy stone, was given by the Swedes to a mineral, which Scheele found to contain a peculiar metal, as he supposed, in the state of an acid, united with lime. The same metallic substance was afterwards found by the Don d'Elhuyarts united with iron and manganese in wolfram.

From the first of these the oxide may be obtained by digesting its powder in thrice its weight of nitric acid; washing the yellow powder that remains, and digesting it in ammonia, by which a portion of it is dissolved. These alternate digestions are to be repeated, and the tungstic oxide precipitated from the ammoniacal solutions by nitric acid. The precipitate is to be washed with water, and exposed to a moderate heat, to expel any ammonia that may adhere to it. Or the mixture may be evaporated to a dry mass, which is to be calcined under a muffle, to dissipate the nitrate of ammonia. From wolfram it may be obtained by the same process, after the iron and manganese have been dissolved by muriatic acid.

The Spanish chemists reduced the oxide of tungsten to the metallic state, by exposing it, moistened with oil, in a crucible lined with charcoal, to an intense heat. After two hours a piece of metal weighing 40 grains, but slightly agglutinated, was found at the bottom of the crucible. Some have attempted its reduction in vain, but Guyton, Ruprecht, and Messrs. Aikin and Allen, have been more successful. The latter gentlemen produced it from the ammoniuret. From 240 grains of this substance, in acicular crystals, exposed for two hours to a powerful wind-furnace, in a crucible lined with charcoal, they obtained a slightly cohering mass of roundish grains, about the size of a pin's head, with a very brilliant metallic lustre, and weighing in the whole 161 grains.

Tungsten is said to be of a grayish-white or iron colour, with considerable brilliancy, very hard and brittle. Its specific gravity Don d'Elhuyarts found to be 17·6; Messrs. Aiken and Allen, above 17·22.

There are two oxides of tungstenum, the brown, and the yellow or tungstic acid.

The brown oxide is formed by transmitting hydrogen gas over tungstic acid, in an ignited glass tube. It has a flea-brown colour, and when heated in the air, it takes fire and burns like tinder, passing into *tungstic acid;* which see.

The brown oxide consists of

Tungstenum,	100
Oxygen,	16·6.—*Berzel.*

Hence, if we regard it as composed of 2 primes oxygen + 1 metal, its composition will be

Tungstenum,	12.05	100
Oxygen,	2·00	16·6

Hence the acid prime ought probably to be $12·05 + 3 = 15·05$ or 15; and that of the metal 12.

But from Berzelius's experiments, tungstate of lime seems to consist of

Tungstic acid,	100	14·50
Lime,	24·12	3·50

The difference indeed is not great.

Sir H. Davy found that tungstenum burns with a deep red light, when heated in chlorine, and forms an orange-coloured volatile substance, which affords the yellow oxide of tungstenum, and muriatic acid, when decomposed by water.

Scheele supposed the white powder obtained by digesting the ore in an acid, adding ammonia to the residuum, and neutralizing it by nitric acid, to be pure acid of tungsten. In fact it has a sour taste, reddens litmus, forms neutral crystallizable salts with alkalis, and is soluble in 20 parts of boiling water. It appears however to be a triple salt, composed of nitric acid, ammonia, and oxide of tungsten; from which the oxide may be obtained in a yellow powder, by boiling with a pure concentrated acid. In this state it contains about 20 per cent. of oxygen; part of which may be expelled by a red heat, when it assumes a green colour.

Tungsten is insoluble in the acids; and its oxide is nearly the same. It appears to be capable of uniting with most other metals, but not with sulphur. Guyton found that the oxide gives great permanence to vegetable colours.

M. Wohler has written a memoir on tungsten and its combinations in the *Annales de Chimie*, xxix. 43. Oxide of tungsten inflames in the air, and becomes tungstic acid. 100 of the former absorb 8 of oxygen; while 100 of metallic tungsten absorb 25 in becoming tungstic acid. M. Wohler describes 3 chlorides of tungsten.

TUNGSTEN OF BASTNAS, OR FALSE TUNGSTEN. See Cerium.

TURBETH MINERAL. Yellow subdeutosulphate of mercury.

TURNSOLE. Heliotropium. See Archil.

TURKEY STONE. Cos Turcica. See Whetslate.

TURMERIC (*terra merita*), *curcuma longa*, is a root brought to us from the East Indies. Berthollet had an opportunity of examining some turmeric that came from Tobago, which was superior to that which is met with in commerce, both in the size of roots and the abundance of the colouring particles. This substance is very rich in colour, and there is no other which gives a yellow colour of such brightness; but it possesses no durability, nor can mordants give it a sufficient degree. Common salt and sal ammoniac are those which fix the colour best, but they render it deeper and make it incline to brown: some recommend a small quantity of muriatic acid. The root must be reduced to powder to be fit for use. It is sometimes employed to give the yellows made with weld a gold cast, and to give an orange tinge to scarlet; but the shade the turmeric imparts soon disappears in the air.

Mr. Guchliche gives two processes for fixing the colour of turmeric on silk. The first consists in aluming in the cold for twelve hours a pound of silk in a solution of two ounces of alum, and dyeing it hot, but without boiling, in a bath composed of two ounces of turmeric and a quart (measure) of aceto-citric acid, mixed with three quarts of water. The second process consists in extracting the colouring particles from the turmeric by aceto-citric acid, in the way described for Brazil wood, and in dyeing the silk alumed as already mentioned in this liquor, either cold or only moderately warm. The colour is rendered more durable by this than by the former process. The first parcel immersed acquires a gold yellow; the colour of the second and third parcels is lighter, but of the same kind; that of the fourth is a straw colour. Mr. Guchliche employs the same process to extract fine and durable colours from fustic, broom, and French berries; he prepares the wool by a slight aluming, to which he adds a little muriatic acid. He seems to content himself in these cases with vinegar or some other vegetable acid, instead of his aceto-citric acid, for the extraction of the colour; he directs that a very small quantity of solution of tin should be put into the dye-bath.

TURNERITE. A rare mineral in small crystals of a yellowish-brown, or brownish-yellow-colour. Brilliant. Primary form an oblique rhombic prism. Scratches fluor, but yields to the knife. Powder grayish-white. It contains alumina, lime, magnesia, and a very little iron. It has been found only on Mount Sorel in Dauphiny.

TURPENTINE is a resinous juice extracted from several trees. Sixteen ounces of Venice turpentine, being distilled with water, yielded four ounces and three drachms of essential oil; and the same quantity, distilled without water, yielded with the heat of a water-bath, two ounces only. When turpentine is distilled or boiled with water till it becomes solid, it appears yellowish; when the process is farther continued, it acquires a reddish-brown colour. On distilling sixteen ounces in a retort with an open fire, increased by degrees, Neumann obtained, first, four ounces of a limpid colourless oil; then two ounces and a drachm of a dark brownish-red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name.

The essential oil, commonly called spirit of turpentine, cannot without singular difficulty be dissolved in alcohol, though turpentine itself is easily soluble in that spirit. One part of the oil may be dissolved in seven parts of alcohol; but on standing a while, the greatest part of the oil separates and falls to the bottom.

TURQUOIS (MINERAL), OR CALAITE. Colours smalt-blue and apple-green. Massive, disseminated, and imitative. Dull. Fracture conchoidal or uneven. Opaque. Harder than felspar, but softer than quartz. Streak white. Sp. gr. 2·86 to 3·0. Its constituents are, alumina 73, oxide of copper 4·5, water 18, oxide of iron 4.—*John.* It occurs in veins in clay-ironstone, and in small pieces in alluvial clay. It has been found only in the neighbourhood of Nichabour in the Khorassan, in Persia. It is very highly prised as an ornamental stone in Persia, and the neighbouring countries. Malchite yields a green streak, but that of calaite is white. *Bone turquois* is phosphate of lime, coloured with oxide of copper.

TUTENAG. This name is given in India to the metal zinc. It is sometimes applied to denote a white metallic compound, brought from China, called also *Chinese copper*, the art of making which is not known in Europe. It is very tough, strong, malleable, may be easily cast, hammered, and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is. Three ingredients of this compound may be discovered by analysis; namely, copper, zinc, and iron.

Some of the Chinese white copper is said to be merely copper and arsenic.

TYPE METAL. The basis of type metal for printers is lead, and the principal article used in communicating hardness is antimony, to which copper and brass in various proportions are added. The properties of a good type metal are, that it should run freely into the mould, and possess hardness without being excessively brittle. The smaller letters are made of a harder composition than those of a larger size. It does not appear that our type-founders are in possession of a good composition for this purpose. The principal defect of their composition appears to be, that the metals do not uniformly unite. In a piece of casting performed at one of our principal founderies, the thickness of which was two inches, I found one side hard and brittle when scraped, and the other side, consisting of nearly half the piece, was soft like lead. The transition from soft to hard was sudden, not gradual. If a parcel of letter of the same size and casting be examined, some of them are brittle and hard, and resist the knife, but others may be bent and cut into shavings. It may easily be imagined, that the duration and neatness of these types must considerably vary. I have been informed, but do not know the fact from trial, that the types cast in Scotland are harder and more uniform in their qualities.—*Nicholson.*

U

ULMIN. This name has been given to a very singular substance lately examined by Klaproth. It differs essentially from every other known body, and must therefore constitute a new and peculiar vegetable principle. It exuded spontaneously from the trunk of a species of elm, which Klaproth conjectures to be the *ulmus nigra*, and was sent to him from Palermo in 1802.

1. In its external characters it resembles gum. It was solid, hard, of a black colour, and had considerable lustre. Its powder was brown. It dissolved readily in the mouth, and was insipid.

2. It dissolved speedily in a small quantity of water. The solution was transparent, of a blackish-brown colour, and, even when very much concentrated by evaporation, was not in the least mucilaginous or ropy; nor did it answer as a paste. In this respect ulmin differs essentially from gum.

3. It was completely insoluble both in alcohol and ether. When alcohol was poured into the aqueous solution, the greater part of the ulmin precipitated in light brown flakes. The remainder was obtained by evaporation, and was not sensibly soluble in alcohol. The alcohol by this treatment acquired a sharpish taste.

4. When a few drops of nitric acid were added to the aqueous solution, it became gelatinous, lost its blackish-brown colour, and a light brown substance precipitated. The whole solution was slowly evaporated to dryness, and the reddish-brown powder which remained was treated with alcohol. The alcohol assumed a golden-yellow colour; and, when evaporated, left a light brown, bitter, and sharp resinous substance.

5. Oxymuriatic acid produced precisely the same effects as nitric. Thus it appears that ulmin, by the addition of a little oxygen, is converted into a resinous substance. In this new state it is insoluble in water. This property is very singular. Hitherto the volatile oils were the only substances known to assume the form of resins. That a substance soluble in water should assume the resinous form with such facility, is very remarkable.

6. Ulmin when burnt emitted little smoke or flame, and left a spongy but firm charcoal, which, when burnt in the open air, left only a little carbonate of potash behind.

Such are the properties of this curious substance, as far as they have been examined by Klaproth.

M. Dobereiner says that gallic acid is convertible into ulmin, by combining the acid with ammonia, and exposing the compound to oxygen.—*Ann. de Chim.* xxiv. 353.

ULTRAMARINE. See AZURE-STONE.

UMBER. See ORES OF IRON.

URANGLIMMER. An ore of uranium, formerly called *green mica*, and by Werner *chalcolite*. See the following article.

URANITE, OR URANIUM. A new metallic substance, discovered by the celebrated Klaproth, in the mineral called *Pechblende*. In this it is in the state of sulphuret. But it likewise occurs as an oxide in the green mica, or uranglimmer, and in the uranochre.

By treating the ores of the metal with the nitric or nitro-muriatic acid, the oxide will be dissolved; and may be precipitated by the addition of a caustic alkali. It is insoluble in water, and of a yellow colour; but a strong heat renders it of a brownish-gray.

To obtain it pure, the ore should be treated with nitric acid, the solution evaporated to dryness, and the residuum heated, so as to render any iron it may contain insoluble. This being treated with distilled water, ammonia is to be poured into the solution, and digested with it for some time, which will precipitate the uranium and retain the copper. The precipitate, well washed with ammonia, is to be dissolved in nitric acid, and crystallized. The green crystals, dried on blotting paper, are to be dissolved in water, and recrystallized, so as to get rid of the lime. Lastly, the nitrate, being exposed to a red heat, will be converted into the yellow oxide of uranium.

It is very difficult of reduction. Fifty grains, after being ignited, were formed into a ball with wax, and exposed, in a well closed charcoal crucible, to the most vehement heat of a porcelain furnace, the intensity of which gave 170° on Wedgewood's pyrometer. Thus a metallic button was obtained, weighing 28 grains, of a dark-gray colour, hard, firmly cohering, fine grained, of very minute pores, and externally glittering. On filing it, or rubbing it with another hard body, the metallic lustre has an iron-gray colour; but in less perfect essays it verges to a brown. Its specific gravity was 8·1. Bucholz, however, obtained it as high as 9.0.

There are probably but two oxides of uranium; the protoxide, which is grayish-black; and the peroxide, which is yellow.

When uranium is heated to redness in an open vessel, it glows like a live coal, and passes into the protoxide, which, from the experiments of Schoübert, consists of

Uranium,	100	15·7
Oxygen,	6·373	1·0

The precipitate thrown down by potash from the nitrate solution is called the *yellow oxide*. It consists of

Uranium,	100	31·4 = 2 primes
Oxygen,	9.359	3·0 = 3

It is generally stated, upon the authority of Bucholz and Schoübert, that there are two oxides of uranium; but the following experiments appear to render this opinion very doubtful.

A quantity of oxide of uranium was prepared, as usual, from the *native oxide* (pechblende), and converted into *nitrate*, by solution in nitric acid and crystallization. The crystals were dissolved in water, and were found still slightly contaminated by copper; their solution was therefore decomposed by excess of ammonia, and the precipitated oxide digested in liquid ammonia, until all traces of copper were removed: it was then washed, and dried in a very moderate heat, and was considered as a pure hydrated *peroxide* of uranium.

But this supposed peroxide dissolved very readily in muriatic acid, without the slightest evolution of chlorine, though there was some effervescence arising from the extrication of a small portion of carbonic acid gas. Moreover, the above hydrated oxide, when heated to dull redness in a glass tube, only lost water and a little carbonic acid; it lost no oxygen, but became black and cohesive, diminishing exceedingly in bulk. A portion heated to bright redness in a platinum crucible, underwent nearly the same changes, contracting into a dark purplish mass, which, however, when triturated into an impalpable powder in an agate mortar, assumed a dingy yellow-brown tint. In this state the oxide of uranium appears only to lose water and a small portion of carbonic acid, accidentally contracted during its precipitation and drying, and not to have altered its state of oxidation, for it remains, as before, perfectly soluble in muriatic and nitric acids, evolving no gas, and forming salts in no respect differing from those produced with the hydrated oxide, recently thrown down from the nitrate.

50 grs. of the yellow hydrated oxide of uranium, dried at 212°, and afterwards exposed under the exhausted receiver, including a surface of sulphuric acid, till it no longer lost weight, were exposed to a white heat, in a platinum capsule. The loss, upon an average of three trials, amounted to 6 grains, so that the composition of the hydrated oxide of uranium is—

88 oxide
12 water
——
100

and, assuming this hydrate to consist of 1 proportional of water and 1 of oxide, the prime equivalent of oxide of uranium will be 66, that of water being 9; and 58 will be the equivalent of uranium, if the above oxide be a compound of 1 proportional of metal and 1 of oxygen.

II. Oxide of uranium dissolves easily and entirely in muriatic acid, and the solution affords, on evaporation, very deliquescent prismatic crystals, of an olive-green colour: if these be dried by heat, they suffer decomposition; but when dried in the exhausted receiver, by sulphuric acid, they crumbled down into a dirty green powder, which is extremely deliquescent. To ascertain the composition of this salt, a portion of the neutral muriate was decomposed by caustic ammonia, and the precipitated oxide, dried, ignited, and weighed, amounted to 112 grains. The filtered ammonio-muriatic solution was rendered slightly acid by nitric acid, and precipitated by nitrate of silver; it afforded 149·8 grains of chloride of silver, equal to 38 grains of muriatic acid. Here, therefore, the muriate of uranium appears to consist of—

Oxide of uranium,	112	100
Muriatic acid,	38	34

Assuming this muriate to consist of 1 proportional of muriatic acid = 37, and 1 of oxide of uranium, the equivalent of the latter will be 109, and that of the metal 101.

III. The recently precipitated oxide of uranium very readily dissolves in nitric acid, and, by careful evaporation, furnishes truncated prismatic crystals of a peculiar iridescent appearance, a brownish-yellow colour, and deliquescent. A portion of these crystals exposed under the exhausted receiver containing sulphuric acid, effloresced into a yellow powder, which was retained *in vacuo* till it ceased to lose weight; 60 grains were then submitted to a red heat, in a platinum capsule, and 36·4 grains of oxide remained. If, therefore, we regard the above salt as a dry nitrate, it will consist of

36·4 oxide of uranium = 60·7
23·6 nitric acid = 39·3
——
100

and, if considered as a compound of 1 proportional of nitric acid, and 1 of oxide of uranium, the number 84 will represent the oxide, and 76 the metal; but we can put no further reliance in the above numbers than as showing the quantity of oxide in the nitrate, dried as above described, for it is probable that in that state the salt still retains a portion of water, which would vitiate the above estimate.

IV. When recently precipitated oxide of uranium is digested in sulphuric acid, diluted with 4 or 5 parts of water, a solution of a green colour is obtained, which has an astringent aluminous taste, and is neutral; but, when evaporated, it deposits successive crusts of a difficultly soluble green salt, probably a subsulphate of uranium, and the supernatant liquor becomes acid, but cannot be made to crystallize.

Dilute sulphuric acid was digested upon

moist oxide of uranium, until a perfectly neutral solution was obtained. A portion of this solution was decomposed by caustic ammonia, and the precipitated oxide, duly washed and ignited, weighed 62 grains. The solution from which the above 62 grains of oxide had been thrown down was neutralized by nitric acid, and precipitated by muriate of baryta. It yielded 85 grains of dry sulphate of baryta, which is equivalent to 22 grains of sulphuric acid: here, therefore, it would appear that dry sulphate of uranium consists of

62 oxide =	68·1
29 acid	31·9
—	——
. 91	100

and, assuming 40 as the prime equivalent of sulphuric acid, that of oxide of uranium will be 85·6, and of the metal 77.6; a number not very different from that obtained by the analysis of the nitrate.

V. When solution of nitrate of uranium is decomposed by carbonate of ammonia, a very slight excess of the latter dissolves a considerable portion of the precipitate, and which, when collected and dried, appears to retain the carbonic acid very feebly, and not to be of uniform composition, but a mixture of oxide and carbonate. In several experiments, in which the supposed carbonate of uranium was decomposed by muriatic acid over mercury, the proportion of carbonic acid evolved was various. The following is the best experiment that was made with the precipitated carbonate: 30 grains were decomposed over mercury, by muriatic acid; they evolved 2.9 cubic inches of carbonic acid = 1·32 grains; 30 grains of the above carbonate, heated to redness, until they ceased to lose weight, lost 3·4 grains. Hence it appears, that 30 grains of the above precipitated carbonate consist of

Oxide,	26·6
Acid,	1·32
Water,	2·08

a quantity of carbonic acid infinitely too small to be considered as saturating the oxide.

Another attempt was made to obtain a pure carbonate of uranium. A quantity of recently precipitated and moist oxide was diffused through water, and carbonic acid was passed through the mixture, by which the oxide was very soon entirely dissolved. This solution was gently heated, when it presently became turbid, and the precipitate being collected and dried at a very moderate heat, was of a dirty yellow colour, and perfectly soluble, with *slight* effervescence, in muriatic and nitric acids. When, however, an attempt was made to collect the carbonic acid evolved, it did not amount to 1 cubical inch from 30 grains; so that it may perhaps be concluded that there is no dry carbonate of uranium which can be regarded as a definite compound.

VI. It has been stated above, that when oxide of uranium is boiled with dilute sulphuric acid, a yellow-green compound, of difficult solubility, is formed, which has there been termed a subsulphate: to determine its composition, 50 grains, carefully washed and dried, were dissolved in nitro-muriatic acid, and the solution decomposed by ammonia; the precipitated oxide of uranium having been separated upon a filter, the clear liquor was precipitated by muriate of baryta, and 29·5 grains of sulphate of baryta, = 10 of sulphuric acid, were obtained; hence the composition of the subsulphate is,

Sulphuric acid,	10
Oxide,	40
	—
	50

and if we consider this as composed of 2 proportionals of oxide and 1 of acid, we obtain the number 80 as the equivalent of oxide of uranium, and 72 as that of the metal. Neither iodine nor the hydriodates occasion any precipitation in solutions of uranium, but ferrocyanate of potassa occasions a fine reddish-brown precipitate in them all, and this although they are considerably acid.

The above experiments were undertaken with a view of determining the equivalent number of uranium; but of the various compounds that have been examined, the sulphates only appear to afford results that can be deemed at all satisfactory; and even these are too much at variance to enable us to assume their analysis as the foundation of a prime equivalent number.—*Journal of Science*, xiii. 86.

M. Arfwedson procures pure oxide of uranium in the following way: Finely pulverized pechblende is to be dissolved by a gentle heat in nitro-muriatic acid, after which a good deal of water is to be added, and a little muriatic acid, if necessary. The undissolved matters are to be removed (sulphur, silica, gangue), and a current of sulphuretted hydrogen gas passed through the solution as long as it affects it. The first precipitate is dark coloured; but the second being sulphuret of arsenic is yellow. On filtration, the liquor is free from copper, lead, and arsenic; but contains iron, cobalt, and zinc. It is now to be digested with a little nitric acid to peroxidize the iron, and then decomposed by carbonate of ammonia, in excess, which leaves the iron and earths. The filtered solution is to be boiled as long as carbonate of ammonia is disengaged; the oxides of uranium, zinc, with part of the oxide of cobalt, fall down, which are to be collected on a filter and dried. It is then to be heated to redness, by which it becomes of a dark green colour, and afterwards by digestion in dilute muriatic acid has the oxides of cobalt and zinc, with a small portion of oxide of uranium, dissolved out, and after washing and drying, pure oxide of uranium remains. About 65 parts were in this way obtained from 100 of pechblende.

The oxide is soluble in dilute sulphuric acid gently heated, and affords lemon-coloured prismatic crystals. Its solution in muriatic acid, in which it is but imperfectly soluble, affords yellowish-green rhomboidal tablets. Phosphoric acid dissolves it, but after some time the phosphate falls down in a flocculent form, and of a pale yellow colour.

It combines with vitrifiable substances, and gives them a brown or green colour. On porcelain, with the usual flux, it produces an orange.

URANOCHRE. An ore of uranium, containing this metal in the oxidized state. See the preceding article.

URATES. Compounds of uric or lithic acid with the salifiable bases. See ACID (LITHIC).

UREA. The best process for preparing urea is to evaporate urine to the consistence of syrup, taking care to regulate the heat towards the end of the evaporation; to add very gradually to the syrup its volume of nitric acid (24° Baume) of 1·20; to stir the mixture, and immerse it in a bath of iced water, to harden the crystals of the acidulous nitrate of urea which precipitate; to wash these crystals with ice-cold water, to drain them, and press them between the folds of blotting paper. When we have thus separated the adhering heterogeneous matters, we redissolve the crystals in water, and add to them a sufficient quantity of carbonate of potash, to neutralize the nitric acid. We must then evaporate the new liquor, at a gentle heat, almost to dryness; and treat the residuum with a very pure alcohol, which dissolves only the urea. On concentrating the alcoholic solution, the urea crystallizes.

The preceding is M. Thenard's process, which Dr. Prout has improved. He separates the nitrate of potash by crystallization, makes the liquid urea into a paste with animal charcoal, digests this with cold water, filters, concentrates, then dissolves the new colourless urea in alcohol, and lastly crystallizes. The process prescribed by Dr. Thomson, in the fifth edition of his System, does not answer.

Urea crystallizes in four-sided prisms, which are transparent and colourless, with a slight pearly lustre. It has a peculiar but not urinous odour; it does not affect litmus or turmeric papers; it undergoes no change from the atmosphere, except a slight deliquescence in very damp weather. In a strong heat it melts, and is partly decomposed and partly sublimed without change. The sp. gr. of the crystals is about 1·35. It is very soluble in water. Alcohol, at the temperature of the atmosphere, dissolves about 20 per cent.; and when boiling, considerably more than its own weight, from which the urea separates on cooling, in its crystalline form. The fixed alkalis and alkaline earths decompose it. It unites with most of the metallic oxides; and forms crystalline compounds with the nitric and oxalic acids.

If cautiously introduced into a retort with a wide short neck, it fuses with a gentle heat: a white fume rises, which is benzoic acid, and condenses on the sides of the receiver: crystallized carbonate of ammonia succeeds, and continues to the end: neither water nor oil rises, but the sublimate is turned brown: the air expelled from the apparatus is impregnated with a smell of garlic and stinking fish: when the heat is very intense, the smell is insupportable. The matter in the retort is then dry, blackish, and covered with a raised white crust, which rises at length in a heavy vapour, and attaches itself to the lower part of the retort. This is muriate of ammonia.

If water be poured on the residuum, it emits a smell of prussic acid. Burned on an open fire it exhales the same smell, gives out ammonia, and leaves one-hundredth of its weight of acrid white ashes, which turn syrup of violets green, and contain a small quantity of carbonate of soda.

The aqueous solution, distilled by a gentle fire, and carried to ebullition, affords very clear water loaded with ammonia. By adding more water, as the liquor became inspissated, Fourcroy and Vauquelin obtained nearly two-thirds of the weight of the urea in carbonate of ammonia, and the residuum was not then exhausted of it. The latter portions, however, were more and more coloured.

This decomposition of an animal substance at the low heat of boiling water is very remarkable, particularly with respect to the carbonic acid. Indeed it appears that a very slight change of equilibrium is sufficient to cause its constituent principles to pass into the state of ammonia, and carbonic, prussic, and acetous acids.

Urea has been recently analysed by Dr. Prout and M. Berard. The following are its constituents:—

	Per Cent.	Per Cent.	Per atom.
Hydrogen,	10.80	6.66	2 = 2.5
Carbon,	19.40	19.99	1 = 7.5
Oxygen,	26.40	26.66	1 = 10.0
Azote,	43.40	46.66	1 = 17.5
	100.00	100.00	37.5

See SUGAR for some remarks on the relation between it and urea. Uric, or lithic acid, is a substance quite distinct from urea in its composition. This fact, according to Dr. Prout, explains, why an excess of urea generally accompanies the phosphoric diathesis, and not the lithic. He has several times seen urea as abundant in the urine of a person where the phosphoric diathesis prevailed, as to crystallize spontaneously on the addition of nitric acid, without being concentrated by evaporation.

As urea and uric acid, says M. Berard, are the most azotized of all animal substances, the secretion of urine appears to have for its object the separation of the excess of azote from the blood, as respiration separates from it the excess of carbon.

Urea has a singular effect on the crystallization of some salts. If muriate of soda be dissolved in a solution of urea, it will crystallize by evaporation, not in cubes, but in octaëdra; muriate of ammonia, on the contrary, treated in the same way, instead of crystallizing in octaëdra, will assume the cubic form. The same effect is produced, if fresh urine be employed.

URIC ACID. See Acid (Lithic).

URINE. This excrementitious fluid, in its natural state, is transparent, of a yellow colour, a peculiar smell and saline taste. Its production as to quantity, and in some measure quality, depends on the seasons and the peculiar constitution of the individual, and is likewise modified by disease. It is observed, that perspiration carries off more or less of the fluid, which would else have passed off by urine; so that the profusion of the former is attended with a diminution of the latter.

From the alkaline smell of urine kept for a certain time, and other circumstances, it was formerly supposed to be an alkaline fluid; but by its reddening paper stained blue with litmus or the juice of radishes, it appears to contain an excess of acid.

The numerous researches made concerning urine have given the following as its component parts: 1, water; 2, urea; 3, phosphoric acid; 4, 5, 6, 7, phosphates of lime, magnesia, soda, and ammonia; 8, 9, 10, 11, lithic, rosacic, benzoic, and carbonic acid; 12, carbonate of lime; 13, 14, muriates of soda and ammonia; 15, gelatin; 16, albumen; 17, resin; 18, sulphur.

Muriate of potash may sometimes be detected in urine, by cautiously dropping into it some tartaric acid; as may sulphate of soda, or of lime, by a solution of muriate of barytes, which will throw down sulphate of barytes together with its phosphate; and these may be separated by a sufficient quantity of muriatic acid, which will take up the latter.

Urine soon undergoes spontaneous changes, which are more or less speedy and extensive, according to its state, as well as the temperature of the air. Its smell, when fresh made, and healthy, is somewhat fragrant; but this presently goes off, and is succeeded by a peculiar odour termed urinous. As it begins to be decomposed, its smell is not very unlike that of sour milk; but this soon changes to a fetid, alkaline odour. It must be observed, however, that turpentine, asparagus, and many other vegetable substances, taken as medicine, or used as food, have a very powerful effect on the smell of the urine. Its tendency to putrefaction depends almost wholly on the quantity of gelatin and albumen it contains; in many cases, where these are abundant, it comes on very quickly indeed.

According to Berzelius, healthy human urine is composed of, water 933, urea 30·10, sulphate of potash 3·71, sulphate of soda 3·16, phosphate of soda 2·94, muriate of soda 4·45, phosphate of ammonia 1·65, muriate of ammonia 1·50, free acetic acid, with lactate of ammonia, animal matter soluble in alcohol, urea adhering to the preceding, altogether 17·14, earthy phosphates, with a trace of fluate of lime 1·0, uric acid 1, mucus of the bladder 0·32, silica 0·3, in 1000·0. The phosphate of ammonia and soda, obtained from urine, by removing by alcohol the urea from its crystallized salts, was called *fusible salt of urine*, or *microcosmic salt;* and was much employed in experiments with the blowpipe.

The changes produced in urine by disease are considerable, and of importance to be known. It is of a red colour, small in quantity, and peculiarly acrid, in inflammatory diseases; but deposits no sediment on standing. Corrosive muriate of mercury throws down from it a copious precipitate. Toward the termination of such diseases, it becomes more abundant, and deposits a copious pink-coloured sediment, consisting of rosacic acid, with a little phosphate of lime and uric acid.

In jaundice it contains a deep yellow colouring matter, capable of staining linen. Muriatic acid renders it green, and this indicates the presence of bile. Sometimes, too, according to Fourcroy and Vauquelin, it contains a substance analogous to the yellow acid, which they formed by the action of nitric acid on muscular fibre.

In hysterical affections it is copious, limpid, and colourless, containing much salt, but scarcely any urea or gelatin.

In dropsy the urine is generally loaded with albumen, so as to become milky, or even coagulate by heat, or on the addition of acids. In dropsy from diseased liver, however, no albumen is present; but the urine is scanty, high coloured, and deposits the pink-coloured sediment.

In dyspepsy, or indigestion, the urine abounds in gelatin, and putrefies rapidly.

In rickets, the urine contains a great deal of a calcareous salt, which has been supposed to be phosphate of lime, but according to Bonhomme it is the oxalate.

Some instances are mentioned, in which females have voided urine of a milky appearance, and containing a certain portion of the caseous part of milk.

But among the most remarkable alterations of urine is that in the diabetes, when the urine is sometimes so loaded with sugar, as to be capable of being fermented into a vinous liquor. Upwards of one-twelfth of its weight of sugar was extracted from some diabetic urine by Cruickshank, which was at the rate of twenty-nine ounces troy a day from one patient. In this disease, however, the urine, though always in very large quantity, is sometimes not sweet, but insipid.

The urine of some animals, examined by Fourcroy, Vauquelin, and Rouelle, jun. appears to differ from that of man in wanting the phosphoric and lithic acids, and containing the benzoic. That of the horse, according to the former two, consists of benzoate of soda .024, carbonate of lime .011, carbonate of soda .009, muriate of potash .009, urea .007, water and mucilage .940. Giese, however, observes, that the proportion of benzoate of soda varies greatly, so that sometimes scarcely any can be found. Notwithstanding the assertions of these chemists, that the urine of the horse contains no phosphoric acid, Giobert affirms that phosphorus may be made from it.

That of the cow, according to Rouelle, contains carbonate, sulphate, and muriate of potash, benzoic acid, and urea: that of the camel differed from it in affording no benzoic acid; that of the rabbit, according to Vauquelin, contains the carbonates of lime, magnesia, and potash, sulphates of potash and lime, muriate of potash, urea, gelatin, and sulphur. All these appear to contain some free alkali, as they turn syrup of violets green. In the urine of domestic fowls, Fourcroy and Vauquelin found lithic acid.

Urine has been employed for making phosphorus, volatile alkali, and sal ammoniac; moulds to the produce of nitre beds; and it is very useful in a putrid state for scouring woollens.

URINE (BLUE). In certain morbid conditions of the body a blue urine has been voided which M. Braconnot has given an account of in the 29th volume of the *Annales de Chimie et Physique*, p. 252. It is a peculiar substance which gives the colour. He proposes to call it *cyanourine*. It resembles the organic salifiable bases in combining with acids, in refusing to dissolve in alkalis, and in the large proportion of carbon which it contains.

URINARY CALCULI. See Calculi (Urinary).

V

VAPOUR. The general principles of the formation of vapour have been explained under the article Caloric, *changes of state*. Some observations have been added under Evaporation and Gas.

Fig. 15. plate XIV. represents one form of the apparatus, which I employed for determining the elastic force of vapours at different temperatures. L, l, are the initial levels of the mercurial columns in the two legs of the syphon barometer. *l*, is the fine wire of platina, to which the quicksilver was made a tangent, at every measurement, by pouring mercury into the open leg, till its vertical pressure equipoised the elastic force of the vapour above *l*. The column added over L, measured directly that elastic force. See the Tables in the Appendix.

VAREC. The French name for kelp, or incinerated sea-weed.

VARNISH. Lac-varnishes or lacquers consist of different resins in a state of solution, of which the most common are mastich, sandarach, lac, benzoin, copal, amber, and asphaltum. The menstrua are either expressed or essential oils, as also alcohol. For a lac-varnish of the first kind, the common painter's varnish is to be united by gently boiling it with some more mastich or colophony, and then diluted again with a little more oil of turpentine. The latter addition promotes both the glossy appearance and drying of the varnish.

Of this sort is the amber-varnish. To make this varnish, half a pound of amber is kept over a gentle fire in a covered iron pot, in the lid of which there is a small hole, till it is observed to become soft, and to be melted together into one mass. As soon as this is perceived, the vessel is taken from off the fire, and suffered to cool a little; when a pound of good painter's varnish is added to it, and the whole suffered to boil up again over the fire, keeping it continually stirring. After this, it is again removed from the fire; and when it is become somewhat cool, a pound of oil of turpentine is to be gradually mixed with it. Should the varnish, when it is cool, happen to be yet too thick, it may be attenuated with more oil of turpentine. This varnish has always a dark brown colour, because the amber is previously half-burned in this operation; but if it be required of a bright colour, amber powder must be dissolved in transparent painter's varnish, in Papin's machine, by a gentle fire.

As an instance of the second sort of lac-varnishes with ethereal oils alone, may be adduced the varnish made with oil of turpentine. For making this, mastich alone is dissolved in oil of turpentine by a very gentle digesting heat, in close glass vessels. This is the varnish used for the modern transparencies employed as window-blinds, fire-screens, and for other purposes. These are commonly prints, coloured on both sides, and afterwards coated with this varnish on those parts that are intended to be transparent. Sometimes fine thin calico, or Irish linen, is used for this purpose; but it requires to be primed with a solution of isinglass, before the colour is laid on.

Copal may be dissolved in genuine Chio turpentine, according to Mr. Sheldrake, by adding it in powder to the turpentine previously melted, and stirring till the whole is fused. Oil of turpentine may then be added to dilute it sufficiently. Or the copal in powder may be put into a long-necked matrass with twelve parts of oil of turpentine, and digested several days on a sand-heat, frequently shaking it. This may be diluted with one-fourth or one-fifth of alcohol. Metallic vessels or instruments, covered with two or three coats of this, and dried in an oven each time, may be washed with boiling water, or even exposed to a still greater heat, without injury to the varnish.

A varnish of the consistence of thin turpentine is obtained for aërostatic machines, by the digestion of one part of elastic gum, or caoutchouc, cut into small pieces, in thirty-two parts of rectified oil of turpentine. Previously to its being used, however, it must be passed through a linen cloth, in order that the undissolved parts may be left behind.

The third sort of lac-varnishes consists in the spirit-varnish. The most solid resins yield the most durable varnishes; but a varnish must never be expected to be harder than the resin naturally is of which it is made. Hence, it is the height of absurdity to suppose that there are any incombustible varnishes, since there is no such thing as an incombustible resin. But the most solid resins by themselves produce brittle varnishes; therefore, something of a softer substance must always be mixed with them, whereby this brittleness is diminished. For this purpose, gum-elemi, turpentine, or balsam of copaiva are employed in proper proportions. For the solution of these bodies the strongest alcohol ought to be used, which may very properly indeed be distilled over alkali, but must not have stood upon alkali. The utmost simplicity in composition, with respect to the number of the ingredients in a formula, is the result of the greatest skill in the art; hence it is no wonder, that the greatest part of the formulas and recipes that we meet with are composed without any principle at all.

In conformity to these rules, a fine colourless varnish may be obtained, by dissolving eight ounces of gum-sandarach and two ounces of Venice turpentine in thirty-two ounces of alcohol by a gentle heat. Five ounces of shell-lac and one of turpentine, dissolved in thirty-two ounces of alcohol by a very gentle heat, give a harder varnish, but of a reddish cast. To these the solution of copal is undoubtedly preferable in many respects. This is effected by triturating an ounce of powder of gum-copal, which has been well dried by a gentle heat, with a drachm of camphor, and, while these are mixing together, adding by degrees four ounces of the strongest alcohol, without any digestion.

Between this and the gold varnish there is only this difference, that some substances that communicate a yellow tinge are to be added to the latter. The most ancient description of two sorts of it, one of which was prepared with oil, and the other with alcohol, is to be found in Alexius Pedemontanus Dei Secreti, Lucca, of which the first edition was published in the year 1557. But it is better prepared, and more durable, when made after the following prescription:—Take two ounces of shell-lac, of arnotto and turmeric of each one ounce, and thirty grains of fine dragon's-blood, and make an extract with twenty ounces of alcohol in a gentle heat.

Oil-varnishes are commonly mixed immediately with the colours, but lac or lacquer varnishes are laid on by themselves upon a burnished coloured ground: when they are intended to be laid upon naked wood, a ground should be first given them of strong size, either alone, or with some earthy colour mixed up with it by levigation. The gold lacquer is simply rubbed over brass, tin, or silver, to give them a gold colour.

Before a resin is dissolved in a fixed oil, it is necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides, in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxygen of the oxide. To accelerate the drying of this varnish, it is necessary to add oil of turpentine.

The essential varnishes consist of a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings.

When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack; but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry.

The coloured resins or gums, such as gamboge, dragon's-blood, &c. are used to colour varnishes.

To give lustre to the varnish after it is laid on, it is rubbed with pounded pumice-stone and water; which being dried with a cloth, the work is afterward rubbed with an oiled rag and tripoli. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powder of starch, and rubbed bright with the palm of the hand.

VAUQUELINITE. Chromate of lead and copper, a mineral which occurs in small crystals on quartz, accompanying the chromate of lead in Siberia.

VEGETABLE KINGDOM. In the mineral kingdom, little of chemical operation takes place, wherein the peculiar locality or disposition of the principles which act upon each other appears to have any considerable effect. The principles, for the most part simple, act upon each other by virtue of their respective attractions: if heat be developed, it is for the most part speedily conducted away; if elastic products be extricated, they in general make their escape;—in a word, we seldom perceive in the operations in the mineral kingdom any arrangement, which at all resembles the artificial dispositions of the chemist.

But in the animal and vegetable kingdoms it is far otherwise. In the former of these, bodies are regularly changed by mechanical division, by digestion, and the application of peculiar solvents, in a temperature exceeding that of the atmosphere; and the whole of the effects are assisted, modified, and kept up by an apparatus for admitting the air of the atmosphere. The subjects of the vegetable kingdom possess undoubtedly a structure less elaborate. They exhibit much less of those energies which are said to be spontaneous. The form of their vessels is much simpler, and, as far as we can perceive, their action is obedient to the changes of the atmosphere in quality and moisture, the mechanical action of winds, the temperature of the weather, and the influence of light. In these organized beings, the chemist discovers principles of a more compounded nature, than any which can be obtained from the mineral kingdom. These do not previously exist in the earth, and must therefore be results of vegetable life.

The most obvious difference between vegetables and animals is, that the latter are in general capable of conveying themselves from place to place; whereas vegetables, being fixed in the same place, absorb, by means of their roots and leaves, such support as is within their reach. This appears on the whole to consist of air and water. The greatest part of the support of animals are the products already elaborated in the vegetable kingdom. The products of these two kingdoms in the hands of the chemist are remarkably different, though perhaps not exclusively so. One of most distinctive characters seems to be the presence of nitrogen or azotic gas, which may be extricated from animal substances by the application of nitric acid, and enters into the composition of the ammonia afforded by destructive distillation. It was long supposed that ammonia was exclusively the product of the animal kingdom, but it is now well known, that certain plants likewise afford it.

When it is considered, that by far the greater part of every organized substance is capable of assuming the elastic form, and being volatilized by heat; that the products are during life brought into combination by slow and long-continued processes, and are kept separate from each other in the vessels of the plant or animal; that these combinations are liable to be altered by the destruction of those vessels, as well as by every notable change of temperature — it will not appear surprising, that the chemical analysis of plants should be in an imperfect state. See Analysis.

In the structure of vegetables we observe the external covering or bark, the ligneous or woody matter, the vessels or tubes, and certain glandular or knotty parts. The comparative anatomy, and immediate uses of these parts, form an object of interesting research, but less immediately within the province of a chemical work.

The nutrition or support of plants appears to require water, earth, light, and air. There are various experiments which have been instituted to show, that water is the only aliment which the root draws from the earth. Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with sheet lead; he watered it for five years with distilled water, and at the end of that time the tree weighed one hundred and sixty-nine pounds three ounces, and the earth in which it had vegetated was found to have suffered a loss of no more than three ounces. Boyle repeated the same experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having lost any perceptible portion of its weight.

Messrs. Duhamel and Bonnet supported plants with moss, and fed them with mere water: they observed, that the vegetation was of the most vigorous kind; and the naturalist of Geneva observes, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the supports before they could suffer any alteration. Mr. Tillet has likewise raised plants, more especially of the gramineous kind, in a similar manner, with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed, that a plant, which weighed three pounds, gained three ounces after a heavy dew. Do we not every day observe hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water? And Braconnot has lately found mustard-seed to germinate, grow, and produce plants, that came to maturity, flowered, and ripened their seed, in litharge, flowers of sulphur, and very small unglazed shot. The last appeared least favourable to the growth of the plants, apparently because their roots could not penetrate between it so easily.

All plants do not demand the same quantity of water; and nature has varied the organs of the several individuals conformably to the necessity of their being supplied with this food. Plants which transpire little, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and, accordingly, they are fixed upon dry rocks, and have scarcely any roots; but plants which require a larger quantity, have roots which extend to a great distance, and absorb humidity throughout their whole surface.

The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same principles which the root draws from the earth. But plants which live in the water, and as it were swim in the element which serves them for food, have no need of roots; they receive the fluid at all their pores; and we accordingly find, that the fucus, the ulva, &c. have no roots whatever.

The dung which is mixed with earths, and decomposed, not only affords the alimentary principles we have spoken of, but likewise favours the growth of the plant by that constant and steady heat which its ulterior decomposition produces. Thus it is that Fabroni affirms his having observed the development of leaves and flowers in that part of a tree only which was in the vicinity of a heap of dung.

From the preceding circumstances, it appears, that the influence of the earth in vegetation is almost totally confined to the conveyance of water, and probably the elastic products from putrefying substances, to the plant.

Vegetables cannot live without air. From the experiments of Priestley, Ingenhousz, and Sennebier, it is ascertained, that plants absorb the azotic part of the atmosphere; and this principle appears to be the cause of the fertility which arises from the use of putrefying matters in the form of manure. The carbonic acid is likewise absorbed by vegetables, when its quantity is small. If in large quantity, it is fatal to them.

Chaptal has observed, that carbonic acid predominates in the fungus, and other subterraneous plants. But by causing these vegetables, together with the body upon which they were fixed, to pass, by imperceptible gradations, from an almost absolute darkness, into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed, which he ascribes to the oxygen of the same acid. Sennebier has observed, that the plants which he watered with water impregnated with carbonic acid transpired an extraordinary quantity of oxygen, which likewise indicates a decomposition of the acid.

Light is almost absolutely necessary to plants. In the dark they grow pale, languish, and die. The tendency of plants toward the light is remarkably seen in such vegetation as is effected in a chamber or place where the light is admitted on one side; for the plant never fails to grow in that direction. Whether the matter of light be condensed into the substance of plants, or whether it act merely as a stimulus or agent, without which the other requisite chemical processes cannot be effected, is uncertain.

It is ascertained, that the processes in plants serve, like those in animals, to produce a more equable temperature, which is for the most part above that of the atmosphere. Dr. Hunter, quoted by Chaptal, observed, by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat, in hotter weather, was always several degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap which, out of the tree, would freeze at 32°, did not freeze in the tree unless the cold were augmented 15° more.

The vegetable heat may increase or diminish by several causes, of the nature of disease; and it may even become perceptible to the touch in very cold weather, according to Buffon.

The principles of which vegetables are composed, if we pursue their analysis as far as our means have hitherto allowed, are chiefly carbon, hydrogen, and oxygen. Nitrogen is a constituent principle of several, but for the most part in small quantity. Potash, soda, lime, magnesia, silex, alumina, sulphur, phosphorus, iron, manganese, and muriatic acid, have likewise been reckoned in the number; but some of these occur only occasionally, and chiefly in very small quantities; and are scarcely more entitled to be considered as belonging to them than gold, or some other substances, that have been occasionally procured from their decomposition.

The following are the principal products of vegetation:—

1. *Sugar.* Crystallizes. Soluble in water and alcohol. Taste sweet. Soluble in nitric acid, and yields oxalic acid.

2. *Sarcocol.* Does not crystallize. Soluble in water and alcohol. Taste bitter sweet. Soluble in nitric acid, and yields oxalic acid.

3. *Asparagin.* Crystallizes. Taste cooling and nauseous. Soluble in hot water. Insoluble in alcohol. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

4. *Gum.* Does not crystallize. Taste insipid. Soluble in water, and forms mucilage. Insoluble in alcohol. Precipitated by silicated potash. Soluble in nitric acid, and forms mucous and oxalic acids.

5. *Ulmin.* Does not crystallize. Taste insipid. Soluble in water, and does not form mucilage. Precipitated by nitric and oxymuriatic acids in the state of resin. Insoluble in alcohol.

6. *Inulin.* A white powder. Insoluble in cold water. Soluble in boiling water; but precipitates unaltered after the solution cools,

Insoluble in alcohol. Soluble in nitric acid, and yields oxalic acid.

7. *Starch.* A white powder. Taste insipid. Insoluble in cold water. Soluble in hot water; opaque and glutinous. Precipitated by an infusion of nutgalls; precipitate redissolved by a heat of 120°. Insoluble in alcohol. Soluble in dilute nitric acid, and precipitated by alcohol. With nitric acid yields oxalic acid and a waxy matter.

8. *Indigo.* A blue powder. Taste insipid. Insoluble in water, alcohol, ether. Soluble in sulphuric acid. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

9. *Gluten.* Forms a ductile elastic mass with water. Partially soluble in water; precipitated by infusion of nutgalls and oxygenized muriatic acid. Soluble in acetic acid and muriatic acid. Insoluble in alcohol. By fermentation becomes viscid and adhesive, and then assumes the properties of cheese. Soluble in nitric acid, and yields oxalic acid.

10. *Albumen.* Soluble in cold water. Coagulated by heat, and becomes insoluble. Insoluble in alcohol. Precipitated by infusion of nutgalls. Soluble in nitric acid. Soon putrefies.

11. *Fibrin.* Tasteless. Insoluble in water and alcohol. Soluble in diluted alkalis, and in nitric acid. Soon putrefies.

12. *Gelatin.* Insipid. Soluble in water. Does not coagulate when heated. Precipitated by infusion of galls.

13. *Bitter principle.* Colour yellow or brown. Taste bitter. Equally soluble in water and alcohol. Soluble in nitric acid. Precipitated by nitrate of silver.

14. *Extractive.* Soluble in water and alcohol. Insoluble in ether. Precipitated by oxygenized muriatic acid, muriate of tin, and muriate of alumina; but not by gelatin. Dyes fawn colour.

15. *Tannin.* Taste astringent. Soluble in water and in alcohol of 0·810. Precipitated by gelatin, muriate of alumina, and muriate of tin.

16. *Fixed oils.* No smell. Insoluble in water and alcohol. Forms soaps with alkalis. Coagulated by earthy and metallic salts.

17. *Wax.* Insoluble in water. Soluble in alcohol, ether, and oils. Forms soap with alkalis. Fusible.

18. *Volatile oil.* Strong smell. Insoluble in water. Soluble in alcohol. Liquid. Volatile. Oily. By nitric acid inflamed, and converted into resinous substances.

19. *Camphor.* Strong odour. Crystallizes. Very little soluble in water. Soluble in alcohol, oils, acids. Insoluble in alkalis. Burns with a clear flame, and volatilizes before melting.

20. *Birdlime.* Viscid. Taste insipid. Insoluble in water. Partially soluble in alcohol. Very soluble in ether. Solution green.

21. *Resins.* Solid. Melt when heated. Insoluble in water. Soluble in alcohol, ether, and alkalis. Soluble in acetic acid. By nitric acid converted into artificial tannin.

22. *Guaiacum.* Possesses the characters of resins; but dissolves in nitric acid, and yields oxalic acid and no tannin.

23. *Balsams.* Possess the characters of the resins, but have a strong smell; when heated, benzoic acid sublimes. It sublimes also when they are dissolved in sulphuric acid. By nitric acid converted into artificial tannin.

24. *Caoutchouc.* Very elastic. Insoluble in water and alcohol. When steeped in ether, reduced to a pulp, which adheres to every thing. Fusible, and remains liquid. Very combustible.

25. *Gum resins.* Form milky solutions with water, transparent with alcohol. Soluble in alkalis. With nitric acid converted into tannin. Strong smell. Brittle, opaque, infusible.

26. *Cotton.* Composed of fibres. Tasteless. Very combustible. Insoluble in water, alcohol, and ether. Soluble in alkalis. Yields oxalic acid to nitric acid.

27. *Suber.* Burns bright, and swells. Converted by nitric acid into suberic acid and wax. Partially soluble in water and alcohol.

28. *Wood.* Composed of fibres. Tasteless. Insoluble in water and alcohol. Soluble in weak alkaline lixivium. Precipitated by acids. Leaves much charcoal when distilled in a red heat. Soluble in nitric acid, and yields oxalic acid.

To the preceding we may add, emetin, fungin, hematin, nicotin, pollenin; the new vegetable alkalis, aconita, atropia, brucia, cicuta, datura, delphia, hyosciama, morphia, picrotoxia, strychnia, veratria; and the various vegetable acids enumerated under the general article ACID.

MM. Dumas and Pelletier published a long and able memoir on the elementary composition and certain characteristic properties of the organic salifiable bases (vegeto-alkalis), in the 24th volume of the *Annales de Chim. et Phys.* p. 163, which was read to the Academy of Sciences, 5th May, 1823. The following is a tabular view of the relations of carbon and azote in these alkaline bodies.

	Carbonic acid.	Azote.
Quinia,	100	5·1
Cinchonia,	100	5·0
Strychnia,	100	4·9
Narcotine,	100	4·5
Brucina,	120	5·0
Morphia,	100	3·2
Veratria,	100	3·2
Emetin,	100	3·1
Cafeine,	100	20·0

M. Robiquet has on more than one occasion stated his doubts of the pre-existence of organic alkalis in vegetables; and he conjectures that they were produced by the re-action of alkaline substances on certain immediate products of plants, and more particularly on what may be named the resinous principle or *resinoide.* The ammonia existing in many vegetables may be supposed to be an active agent in such a transformation.—*Annales de Chimie,* xxxi. 67.

VEGETATION (SALINE). M. Chaptal has given us a good memoir on this subject, in the Journal de Physique for October 1788, entitled Observations on the Influence of the Air and Light upon the Vegetation of Salts.

In the operations in the large way, of his manufactory of medical and chemical products, he often observed that salts, particularly the metallic, vegetated on the side most exposed to the light; and the frequency of the effect induced him to make some direct experiments on the subject. For this purpose he took several capsules of glass, and covered the half of each, as well above as below, with black silk. At the same time, he prepared solutions of almost all the earthy, alkaline, or metallic compound salts in distilled water, at the temperature of the atmosphere. These capsules were placed on tables in a well closed chamber, which had no chimney, and of which the doors and windows were carefully stopped up, in order that the evaporation might not be hastened by any agitation of the air. Reflected light, by which I understand the light from the clouds, was admitted through a small aperture in one of the window-shutters. By this management, as well as the disposition of the capsules, one-half of each of their respective cavities received light from the aperture, and the other was almost perfectly in darkness. The solutions were then carefully poured into the capsules by means of a funnel resting on the middle of the bottom, so that the border of the fluid was neat and uniform, without any irregularity or drop of the fluid falling on the bare surface of the glass.

Upwards of two hundred experiments were made, with variations of the principal trials, so as to leave no doubt with regard to the constancy of the results. The most remarkable fact is, that the vegetation took place on those surfaces only which were illuminated. This phenomenon was so striking in most of the solutions, that in the space of a few days, and frequently even within one single day, the salt was elevated several lines above the liquor upon the enlightened surface, while there did not appear the smallest crust or edge on the dark part. Nothing could be more interesting than to observe this vegetation, projecting frequently more than an inch, and marking the line of distinction between the illuminated and dark parts of the vessel. The sulphates of iron, of zinc, and other metals, more especially presented this appearance. It was generally observed, that the vegetation was strongest toward the most enlightened part.

This phenomenon may be rendered still more interesting, by directing the vegetation at pleasure toward the different parts of the vessel. For this purpose, nothing more is required than to cover the several parts in succession. For the vegetation always takes place in the enlightened parts, and quickly ceases in that which is covered.

When the same solution has stood for several days, the insensible evaporation gradually depresses its surface, and a crust or edge of salt is left in the obscure part. But the salt never rises, or at least very imperfectly, above the liquor, and cannot be compared with the true vegetation.

When salts are suffered to vegetate in this manner, the spontaneous evaporation of the fluid affords very few crystals. All the saline matter extends itself on the sides of the vessel.

VEINS. The ores of metals are frequently found to fill certain clefts in mountains. These masses, when they run out in length, are called veins. Inconsiderable veins, which diverge from the principal, are called slips; and such masses of ore as are of considerable magnitude, but no great length, are called bellies, or stock-works.

VERATRIA. A new vegetable alkali, discovered lately by MM. Pelletier and Caventou, in the *veratrum sabatilla* or cevadilla, the *veratrum album* or white hellebore, and the *colchicum autumnale* or meadow saffron.

The seeds of cevadilla, after being freed from an unctuous and acrid matter by ether, were digested in boiling alcohol. As this infusion cooled, a little wax was deposited; and the liquid being evaporated to an extract, redissolved in water, and again concentrated by evaporation, parted with its colouring matter. Acetate of lead was now poured into the solution, and an abundant yellow precipitate fell, leaving the fluid nearly colourless. The excess of lead was thrown down by sulphuretted hydrogen, and the filtered liquor being concentrated by evaporation, was treated with magnesia, and again filtered. The precipitate, boiled in alcohol, gave a solution, which, on evaporation, left a pulverulent matter, extremely bitter, and with decidedly alkaline characters. It was at first yellow, but by solution in alcohol, and precipitation by water, was obtained in a fine white powder.

The precipitate by the acetate of lead gave, on examination, gallic acid; and hence it is concluded that the new alkali existed in the seed as a gallate.

Veratria was found in the other plants above mentioned. It is white, pulverulent, has no odour, but excites violent sneezing. It is very acrid, but not bitter. It produced violent vomiting in very small doses, and, according to some experiments; a few grains may cause death. It is very little soluble in cold water. Boiling water dissolves about $\frac{1}{1000}$ part, and becomes acrid to the taste. It is very soluble in alcohol, and rather less soluble in ether. It fuses at 122° F., and then appears like wax. On cooling, it becomes an amber-coloured translucent mass. Heated more highly, it swells, decomposes, and burns. Decomposed by oxide of copper, it gave no trace of azote. It acts on test papers like an alkali, and forms salts uncrystallizable by evaporation. The salts appear like a gum. The supersulphate only seems to present crystals. Strong solutions of these salts are partially decomposed by water. Veratria falls down, and the solution becomes acid. The bisulphate appears to consist of,

Veratria,	93·723	100
Sulphuric acid,	6·227	6·6441

The muriate is composed of,

Veratria,	95·8606	100
Muriatic acid,	4·1394	4·3181

Iodine and chlorine produce with veratria an iodate, hydriodate, chloride, and muriate.

VERDIGRIS. A crude acetate of copper. Mr. Phillips has lately published the following analyses of verdigris.

	French.	English.
Acetic acid,	29·3	29·62
Peroxide of copper,	43·5	44·25
Water,	25·2	25·51
Impurity,	2·0	0·62
	100·0	100·00

Phillips' Annals, No. 21.

VERDITER is a blue pigment, obtained by adding chalk or whiting to the solution of copper in aquafortis. Dr. Merret says, that it is prepared in the following manner: a quantity of whiting is put into a tub, and upon this the solution of the copper is poured. The mixture is to be stirred every day for some hours together, till the liquor loses its colour. The liquor is then to be poured off, and more solution of copper is to be added. This is to be repeated till the whiting has acquired the proper colour. Then it is to be spread on large pieces of chalk, and dried in the sun.

It appears from M. Pelletier's analysis, that 100 grains of the very best verditer contain, of carbonic acid 30, of water $3\frac{1}{3}$, of pure lime 7, of oxygen $9\frac{2}{3}$, and of pure copper 50. The author remarks, that the verditers of inferior quality contain more chalk and less copper.

VERJUICE. A kind of harsh, austere vinegar, made of the expressed juice of the wild apple, or crab. The French give this name to unripe grapes, and to the sour liquor obtained from them.

VERMILION. The red sulphuret of mercury, or cinnabar.

VESSELS (CHEMICAL). See APPARATUS.

VESUVIAN. *Idocrase* of Haüy; a subspecies of pyramidal garnet. Colours green and brown. Massive, disseminated, and crystallized. Primitive form, a pyramid of 129° 30′ and 74° 12′. The following secondary forms occur; a rectangular four-sided prism variously acuminated, bevelled or truncated. The lateral planes of the prism are longitudinally streaked. Glistening vitreo-resinous. Cleavage imperfect, but in the direction of the diagonals. Fracture small grained uneven. Translucent. Refracts double. Scratches felspar. Brittle. Sp. gr. 3·3 to 3·4. It becomes electrical by friction. Before the blowpipe it melts without addition into a yellowish, and faintly translucent glass. Its constituents are, silica 35·5, lime 33, alumina 22·25, oxide of iron 7·5, oxide of manganese 0·25, loss 1.5.—*Klaproth.* It occurs in considerable abundance, in unaltered ejected rocks, in the vicinity of Vesuvius. The rare blue variety is found at Sonland, in Tellemark, in Norway. At Naples it is cut into ring-stones.

VINEGAR. See FERMENTATION (ACETOUS); and also ACID (ACETIC), where the mode of making it is given.

VINEGAR FROM WOOD. M. Stolze, apothecary at Halle, has discovered a method of purifying vinegar from wood, by treating it with sulphuric acid, manganese, and common salt, and afterwards distilling it over.

VINEGAR OF SATURN. Solution of acetate of lead.

VINEGAR (RADICAL). Acetic acid.

VIOLINE. A supposed new vegeto-alkali, thought to exist in the *viola odorata*. It has properties analogous to emetine, and may be extracted from the root, leaves, flowers, and seeds of the plant.—*Journ. de Pharm. Jan.* 1824.

VITAL AIR. See OXYGEN.

VITRIFICATION. See GLASS; also SILICA.

VITRIOL, *blue*, *green*, *red*, *white*. See ORES of COPPER, IRON, COBALT, ZINC.

VITRIOLIC ACID. See ACID (SULPHURIC).

VIVIANITE. Phosphate of iron.

VOLATILE ALKALI. See AMMONIA.

VOLATILITY. The property of bodies by which they are disposed to assume the vaporous or elastic state, and quit the vessels in which they are placed.

VOLCANOES. The combustion of these enormous masses of bitumen which are deposited in the bowels of the earth produces volcanoes. They owe their origin more especially to the strata of pyritous coal. The decomposition or action of water upon the pyrites determines the heat, and the production of a great quantity of hydrogen, which exerts itself against the surrounding obstacles, and at length breaks them. This effect appears to be the chief cause of earthquakes; but when the concourse of air facilitates the combustion of the bitumen and the hydrogen, the flame is seen to issue out of the chimneys or vents which are made; and this occasions the fire of volcanoes.

There are many volcanoes still in an active state on our globe, independent of those of Italy, which are the most known. The Abbé Chappe has described three burning in Siberia. Anderson and Von Troil have described those of Iceland; Asia and Africa contain several; and we find the remains of these fires or volcanic products in all parts of the globe.

Naturalists inform us that all the southern islands have been volcanized; and they are seen daily to be formed by the action of these subterraneous fires. The black colour of the stones, their spongy texture, the other products of fire, and the identity of these substances with those of the volcanoes at present burning, are all in favour of the opinion that their origin was the same.

When the decomposition of the pyrites is advanced, and the vapours and elastic fluids can no longer be contained in the bowels of the earth, the ground is shaken, and exhibits the phenomenon of earthquakes. Mephitic vapours are multiplied on the surface of the ground, and dreadful hollow noises are heard. In Iceland the rivers and springs are swallowed up; a thick smoke, mixed with sparks and lightning, is then disengaged from the crater; and naturalists have observed, when the smoke of Vesuvius takes the form of a pine, the eruption is near at hand.

To these preludes, which show the internal agitation to be great, and that obstacles oppose the issue of the volcanic matters, succeeds an eruption of stones and other products, which the lava drives before it; and, lastly, appears a river of lava, which flows out, and spreads itself down the side of the mountain. At this period the calm is restored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter sometimes cause the sides of the mountain to open; and this is the cause which has successively formed the smaller mountains that surround volcanoes. Montenuevo, which is a hundred and eighty feet high, and three thousand in breadth, was formed in a night.

This crisis is sometimes succeeded by an eruption of ashes, which darkens the air. These ashes are the last result of the alteration of the coals; and the matter which is first thrown out is that which the heat has half vitrified. In the year 1767 the ashes of Vesuvius were carried twenty leagues out to sea, and the streets of Naples were covered with them. The report of Dion, concerning the eruption of Vesuvius in the reign of Titus, wherein the ashes were carried into Africa, Egypt, and Syria, seems to be fabulous. M. de Saussure observes, that the soil of Rome is of this character, and that the famous catacombs are all made in the volcanic ashes.

It must be admitted, however, that the force with which all these products are thrown is astonishing. In the year 1769, a stone, twelve feet high and four in circumference, was thrown to the distance of a quarter of a mile from the crater: and in the year 1771 Sir William Hamilton observed stones of an enormous size, which employed eleven seconds in falling. This indicates an elevation of near two thousand feet.

The eruption of volcanoes is frequently aqueous; the water which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, destroyed Portici and Torre del Greco. Sir W. Hamilton saw boiling water ejected. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites.

Some eruptions are of a muddy substance; and these form the tuffa and the pouzzolano. The eruption which buried Herculaneum is of this kind. Sir W. Hamilton found an antique head, the impression of which was well enough preserved to answer the purpose of a mould. Herculaneum at the least depth is seventy feet under the surface of the ground, and in many places one hundred and twenty.

The pouzzolano is of various colours. It is usually reddish, sometimes gray, white, or green: it frequently consists of pumice-stone in powder; but sometimes it is formed of oxided clay. One hundred parts of red pouzzolano afforded Bergmann silex 55, alumina 20, lime 5, iron 20.

When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which forms the currents of lava, the volcanic causeways, &c. The surface of the lava cools, and forms a solid crust, under which the liquid lava flows. After the eruption, this crust sometimes remains, and forms hollow galleries, which Messrs. Hamilton and Ferber have visited: it is in these hollow places that the sal ammoniac, the muriate of soda, and other substances sublime. A lava may be turned out of its course by opposing banks or dykes against it: this was done in 1669 to save Catania; and Sir William Hamilton proposed it to the king of Naples to preserve Portici.

The currents of lava sometimes remain several years in cooling. Sir William Hamilton observed, in 1769, that the lava which flowed in 1766 was still smoking in some places.

Lava is sometimes swelled up and porous. The lightest is called *pumice-stone.*

The substances thrown out by volcanoes are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, felspar, mica, shells, schorl, &c.

The fire of volcanoes is seldom strong enough to vitrify the matters it throws out. We know only of the yellowish capillary and flexible glass thrown out by the volcanoes of the island of Bourbon, on the 14th of May 1766, (M. Commerson), and the lapis gallinaceus ejected by Hecla. Mr. Egolfrigouson, who is employed by the observatory at Copenhagen, has settled in Iceland. where he uses a mirror of a telescope which he has made out of the black agate of Iceland.

The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been every-where volcanized. Chaptal observed several ancient volcanoes at present cultivated; and the line which separates the other earths from the volcanic earth constitutes the limit of vegetation. The ground over the ruins of Pompeii is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by nature to extract virgin earth out of the bowels of the globe, and repair the exhausted surface.

The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other; which denote eruptions made at distances of time very remote from each other, since in some instances it appears to have required nearly two thousand years before lava was fit to receive the plough. In this respect, however, lavas differ very widely, so that our reasoning from them must at best be very vague. An argument has been drawn from this phenomenon to prove the antiquity of the globe; but the silence of the most ancient authors concerning the volcanoes of the kingdom of France, of which we find such frequent traces, indicates that these volcanoes have been extinguished from time immemorial; a circumstance which carries their existence to a very distant period. Beside this, several thousand years of connected observations have not afforded any remarkable change in Vesuvius or Ætna: nevertheless these enormous mountains are all volcanized, and consequently formed of strata applied one upon the other. The prodigy becomes much more striking, when we observe, that all the surrounding country, to very great distances, has been thrown out of the bowels of the earth.

The height of Vesuvius above the level of the sea is three thousand six hundred and fifty-nine feet; its circumference thirty-four thousand four hundred and forty-four. The height of Ætna is ten thousand and thirty-six feet; and its circumference one hundred and eighty thousand.

The various volcanic products are applicable to several uses.

1. Pouzzolano is of admirable use for building in the water: when mixed with lime it speedily fixes itself; and water does not soften it, for it becomes continually harder and harder. Chaptal has proved that oxided ochres afford the same advantage for this purpose: they are made into balls, and baked in a potter's furnace in the usual manner. The experiments made at Sette, by the commissary of the province, prove, that they may be substituted with the greatest advantage instead of the pouzzolano of Italy.

2. Lava is likewise susceptible of vitrification; and in this state it may be blown into opaque bottles of the greatest lightness, which Chaptal says he has done at Erepian and at Alais. The very hard lava, mixed in equal parts with wood-ashes and soda, produced, he says, an excellent green glass. The bottles made of it were only half the weight of common bottles, and much stronger, as was proved by Chaptal's experiments, and those which M. Joly de Fleury ordered to be made under his administration.

3. Pumice-stone likewise has its uses; it is more especially used to polish most bodies which are somewhat hard. It is employed in the mass or in powder, according to the intended purpose. Sometimes, after levigation, it is mixed with water to render it softer.

VOLCANITE. Augite.

VULPINITE. Colour greyish-white. Massive. Splendent. Fracture foliated. Fragments rhomboidal. In distinct granular concretions. Translucent on the edges. Soft. Brittle. Sp. gr. 2·878. It melts easily before the blowpipe into a white opaque enamel. Its constituents are, sulphate of lime 92, silica 8. It occurs along with granular foliated limestone at Vulpino, in Italy.

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WACKE. A mineral substance intermediate between clay and basalt. It is sometimes simple; but when it inclines to basalt, it contains hornblende and mica. It is sometimes spotted, and these spots are unformed crystals of hornblende, resembling the unformed crystals of felspar in certain varieties of porphyry. It never contains augite or olivine. When it approaches to an amygdaloid, it is vesicular. Its colour is greenish-grey. Massive and vesicular. Dull. Opaque. Streak shining. Soft. Easily frangible. Sp. gr. 2·55 to 2·9. Fuses like basalt. It seldom contains petrifactions. It occurs sometimes in beds and veins, and these veins contain very small portions of ores of different kinds, as bismuth, silver-glance, and magnetic ironstone.

WADD. This name is given to plumbago, or black lead.

WADD, BLACK. An ore of manganese found in Derbyshire. It is remarkable for the property of taking fire when mixed with linseed oil.

WASH. The technical term for the fermented liquor, of whatever kind, from which spirit is intended to be distilled. See ALCOHOL and DISTILLATION.

WATER. It is scarcely necessary to give any definition or description of this universally known fluid. It is a very transparent fluid, possessing a moderate degree of activity with regard to organized substances, which renders it friendly to animal and vegetable life, for both which it is indeed indispensably necessary. Hence it acts but slightly on the organs of sense, and is therefore said to have neither taste nor smell. It appears to possess considerable elasticity, and yields in a perceptible degree to the pressure of air in the condensing machine, as Canton proved, by including it in an open glass vessel with a narrow neck.

The solubility or insolubility of bodies in this fluid composes a large part of the science of chemistry. See SALT.

The habitudes of water with heat have been detailed under *Caloric* and *Temperature*.

Water is not only the common measure of specific gravities, but the tables of these may be usefully employed in the admeasurement of irregular solids; for one cubic foot is very nearly equal to 1000 ounces avoirdupois. The numbers of the table denoting the specific gravities do therefore denote likewise the number of ounces avoirdupois in a cubic foot of each substance.

Native water is seldom, if ever, found perfectly pure. The waters that flow within or upon the surface of the earth contain various earthy, saline, metallic, vegetable, or animal particles, according to the substances over or through which they pass. Rain and snow waters are much purer than these, although they also contain whatever floats in the air, or has been exhaled along with the watery vapours.

The purity of water may be known by the following marks or properties of pure water:—

1. Pure water is lighter than water that is not pure.

2. Pure water is more fluid than water that is not pure.

3. It has no colour, smell, or taste.

4. It wets more easily than the waters containing metallic and earthy salts, called hard waters, and feels softer when touched.

5. Soap, or a solution of soap in alcohol, mixes easily and perfectly with it.

6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mercury, in nitric acid, or a solution of acetate of lead in water.

For the habitudes of water with saline matter, see SALT, and the different substances.

Water was, till modern times, considered as an elementary or simple substance.

Previous to the month of October 1776, the celebrated Macquer, assisted by M. Sigaud de la Fond, made an experiment by burning hydrogen gas in a bottle without explosion, and holding a white china saucer over the flame. His intention appears to have been that of ascertaining whether any fuliginous smoke was produced, and he observes that the saucer remained perfectly clean and white, but was moistened with perceptible drops of a clear fluid, resembling water; and which, in fact, appeared to him and his assistant to be nothing but pure water.

He does not say whether any test was applied to ascertain this purity, neither does he make any remark on the fact.[*]

In the month of September 1777, Messrs. Bucquet and Lavoisier, not being acquainted with the fact which is incidentally and concisely mentioned by Macquer, made an experiment to discover what is produced by the combustion of hydrogen. They fired five or six pints of hydrogen in an open and wide-mouthed bottle, and instantly poured two ounces of lime water through the flame, agitating the bottle during the time the combustion lasted. The result of this experiment showed, that carbonic acid was not produced.[†]

Before the month of April 1781, Mr. John Warltire, encouraged by Dr. Priestley, fired a mixture of common air and hydrogen gas in a close copper vessel, and found its weight diminished. Dr. Priestley, likewise, before the same period, fired a like mixture of hydrogen and oxygen gas in a closed glass vessel, Mr. Warltire being present. The inside of the vessel, though clean and dry before, became dewy, and was lined with a sooty substance.[‡] These experiments were afterwards repeated by Mr. Cavendish and Dr. Priestley; and it was found, that the diminution of weight did not take place, neither was the sooty matter perceived.[*] These circumstances, therefore, must have arisen from some imperfection in the apparatus or materials with which the former experiments were made.

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[*] Dictionnaire de Chimie, 2d edition, Paris, 1778, Art. Gas Inflammable, vol. ii. p. 314, 315.

[†] Acad. Par. 1781, p. 470.

[‡] Priestley, v. 395.

It was in the summer of the year 1781, that Mr. Henry Cavendish was busied in examining what becomes of the air lost by combustion, and made those valuable experiments which were read before the Royal Society on the 15th of January 1784.[†] He burned 500,000 grain measures of hydrogen gas, with about 2½ times the quantity of common air, and by causing the burned air to pass through a glass tube eight feet in length, 135 grains of pure water were condensed. He also exploded a mixture of 19,500 grain measures of oxygen gas, and 37,000 of hydrogen, in a close vessel. The condensed liquor was found to contain a small portion of nitric acid, when the mixture of the air was such, that the burned air still contained a considerable proportion of oxygen. In this case it may be presumed, that some of the oxygen combines with a portion of nitrogen present.

In the mean time, M. Lavoisier continued his researches, and during the winter of 1781-1782, together with M. Gingembre, he filled a bottle of six pints with hydrogen, which being fired, and two ounces of lime water poured in, was instantly stopped with a cork, through which a flexible tube communicating with a vessel of oxygen was passed. The inflammation ceased, except at the orifice of the tube through which the oxygen was pressed, where a beautiful flame appeared. The combustion continued a considerable time, during which the lime water was agitated in the bottle. Neither this, nor the same experiment repeated with pure water, and with a weak solution of alkali instead of lime water, afforded the information sought after, for these substances were not at all altered.

The inference of Mr. Warltire, respecting the moisture on the inside of the glass in which Dr. Priestley first fired hydrogen and common air, was, that these airs, by combustion, deposited the moisture they contained. Mr. Watt, however, inferred from these experiments, that water is a compound of the burned airs, which have given out their latent heat by combustion; and communicated his sentiments to Dr. Priestley in a letter dated April 26, 1783.[*]

It does not appear,[†] that the composition of water was known or admitted in France, till the summer of 1783, when M. Lavoisier and M. de la Place, on the 24th of June, repeated the experiment of burning hydrogen and oxygen in a glass vessel over mercury, in a still greater quantity than had been burned by Mr. Cavendish. The result was nearly five gros of pure water.[‡] M. Monge made a similar experiment at Paris, nearly at the same time, or perhaps before.

This assiduous and accurate philosopher then proceeded, in conjunction with M. Meusnier, to pass the steam of water through a red-hot iron tube, and found that the iron was oxidized, and hydrogen disengaged; and the steam of water being passed over a variety of other combustible or oxidable substances, produced similar results, the water disappearing and hydrogen being disengaged. These capital experiments were accounted for by M. Lavoisier, by supposing the water to be decomposed into its component parts, oxygen and hydrogen, the former of which unites with the ignited substance, while the latter is disengaged.

The grand experiment of the composition of water by Fourcroy, Vauquelin, and Seguin, was begun on Wednesday, May 13, 1790, and was finished on Friday the 22d of the same month. The combustion was kept up 185 hours with little interruption, during which time the machine was not quitted for a moment. The experimenters alternately refreshed themselves when fatigued, by lying for a few hours on mattresses in the laboratory.

To obtain the hydrogen, 1. Zinc was melted and rubbed into a powder in a very hot mortar. 2. This metal was dissolved in concentrated sulphuric acid diluted with seven parts of water. The air procured was made to pass through caustic alkali. To obtain the oxygen, two pounds and a half of crystallized hyper-oxymuriate of potash were distilled, and the air was transferred through caustic alkali.

The volume of hydrogen employed was 25963·568 cubic inches, and the weight was 1039·358 grains.

The volume of oxygen was 12570·942, and the weight was 6209·869 grains.

The total weight of both elastic fluids was 7249·227.

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[*] Phil. Trans. lxxiv. 126. Dr. Priestley supposed the sooty matter to be part of the mercury used in filling the vessel, Phil. Trans. lxxiv. 332.

[†] M. Lavoisier relates, that Dr. Blagden, Sec. R. S. (who was present at the performing of the capital experiment of burning hydrogen and oxygen gas in a closed vessel on the 24th June 1783), informed him, that Mr. Cavendish had already done the same thing, and obtained water. See the Memoirs of the Royal Academy at Paris for 1781, p. 472; also Phil. Trans. vol. lxxiv. p. 134.

[*] Phil. Trans. vol. lxxiv. p. 330.

[†] Compare Phil. Trans. vol. lxxiv. p. 138, with the Memoirs of the Royal Academy at Paris for 1781, pages 472 and 474.

[‡] The ounce poids de marc being 472·2 grains troy, this quantity will be 296 English grains.

The weight of water obtained was 7244 grains, or 12 ounces 4 gros 45 grains.

The weight of water which should have been obtained was 12 ounces 4 gros 49·227 grains.

The deficit was 4·227 grains.

The quantity of azotic air before the experiment was 415·256 cubic inches, and at the close of it 467. The excess after the experiment was consequently 51·744 cubic inches. This augmentation is to be attributed, the academicians think, to the small quantity of atmospheric air in the cylinders of the gasometers at the time the other airs were introduced. These additional 51 cubic inches could not arise from the hydrogen, for experiment showed that it contained no azotic air. Some addition of this last fluid, the experimenters think, cannot be avoided, on account of the construction of the machine.

The water being examined, was found to be as pure as distilled water. Its specific gravity to distilled water was as 18671 : 18670.

The decomposition of water is most elegantly effected by Electricity; which see.

The composition of water is best demonstrated by exploding 2 volumes of hydrogen and 1 of oxygen, in the eudiometer. They disappear totally, and pure water results. A cubic inch of this liquid, at 60°, weighs 252·52 grains, consisting of

28·06 grains hydrogen, and
224·46 oxygen.

The bulk of the former gas is	1325 cubic inches.
That of the latter is	662
	1987

Hence there is a condensation of nearly two thousand volumes into one; and one volume of water contains 662 volumes of oxygen. The prime equivalent of water is 1·125; composed of a prime of oxygen = 1·0 + a prime of hydrogen = 0·125; or 9 parts by weight of water consist of 8 oxygen + 1 hydrogen.

WATER OF CRYSTALLIZATION. Many salts require a certain proportion of water to enable them to retain the crystalline form, and this is called their water of crystallization. Some retain this so feebly, that it flies off on exposure to the air, and they fall to powder. These are the efflorescent salts. Others have so great an affinity for water, that their crystals attract more from the air, in which they dissolve. These are the deliquescent.

WATERS (MINERAL). The examination of mineral waters with a view to ascertain their ingredients, and thence their medicinal qualities, and the means of compounding them artificially, is an object of considerable importance to society. It is likewise a subject which deserves to be attended to, because it affords no mean opportunity for the agreeable practice of chemical skill. But this investigation is more especially of importance to the daily purposes of life, and the success of manufactures. It cannot but be an interesting object, to ascertain the component parts and qualities of the waters daily consumed by the inhabitants of large towns and vicinities. A very minute portion of unwholesome matter, daily taken, may constitute the principal cause of the differences in salubrity which are observable in different places. And with regard to manufactures, it is well known to the brewer, the paper-maker, the bleacher, and a variety of other artists, of how much consequence it is to them, that this fluid should either be pure, or at least not contaminated with such principles as tend to injure the qualities of the articles they make. This analysis has accordingly employed the attention of the first chemists. Bergmann has written an express treatise on the subject, which may be found in the first volume of the English translation of his Essays. Kirwan published a valuable volume on the analysis of waters.

The topography of the place where these waters rise is the first thing to be considered. By examining the ooze formed by them, and the earth or stones through which they are strained and filtered, some judgment may be formed of their contents. In filtering through the earth, and meandering on its surface, they take with them particles of various kinds, which their extreme attenuation renders capable of being suspended in the fluid that serves for their vehicle. Hence we shall sometimes find in these waters siliceous, calcareous, or argillaceous earth; and at other times, though less frequently, sulphur, magnesian earth, or, from the decomposition of carbonated iron, ochre.

The following are the ingredients that may occur in mineral waters:—

1. Air is contained in by far the greater number of mineral waters: its proportion does not exceed 1-28th of the bulk of the water.

2. Oxygen gas was first detected in waters by Scheele. Its quantity is usually inconsiderable; and it is incompatible with the presence of sulphuretted hydrogen gas or iron.

3. Hydrogen gas was first detected in Buxton water by Dr. Pearson. Afterward it was discovered in Harrowgate waters by Dr. Garnet, and in those of Lemington Priors by Mr. Lambe.

4. Sulphuretted hygrogen gas constitutes the most conspicuous ingredient in those waters, which are distinguished by the name of hepatic or sulphurous.

The only acids hitherto found in waters, except in combination with a base, are the carbonic, sulphuric, and boracic.

5. Carbonic acid was first discovered in

Pyrmont water by Dr. Brownrigg. It is the most common ingredient in mineral waters, 100 cubic inches of the water generally containing from 6 to 40 cubic inches of this acid gas. According to Westrumb, 100 cubic inches of Pyrmont water contain 187 cubic inches of it, or almost double its own bulk.

6. Sulphurous acid has been observed in several of the hot mineral waters in Italy, which are in the neighbourhood of volcanoes.

7. The boracic acid has also been observed in some lakes in Italy.

The only alkali which has been observed in mineral waters, uncombined, is soda; and the only earthy bodies are silex and lime.

8. Dr. Black detected soda in the hot mineral waters of Geyser and Rykum in Iceland; but in most other cases the soda is combined with carbonic acid.

9. Silex was first discovered in waters by Bergmann. It was afterward detected in those of Geyser and Rykum by Dr. Black, and in those of Karlsbad by Klaproth. Hassenfratz observed it in the waters of Pougues, as Brezé did in those of Pu. It has been found also in many other mineral waters.

10. Lime is said to have been found uncombined in some mineral waters; but this has not been proved in a satisfactory manner.

The only salts hitherto found in mineral waters are the following; sulphates, nitrates, muriates, carbonates, and borates; and of these the carbonates and muriates occur by far most commonly, and the borates and nitrates most rarely.

11. Sulphate of soda is not uncommon, especially in those mineral waters which are distinguished by the epithet *saline*.

12. Sulphate of ammonia is found in mineral waters near volcanoes.

13. Sulphate of lime is exceedingly common in water. Its presence seems to have been first detected by Dr. Lister in 1682.

14. Sulphate of magnesia is almost constantly an ingredient in those mineral waters which have purgative properties. It was detected in Epsom waters in 1610, and in 1696 Dr. Grew published a treatise on it.

15. Alum is sometimes found in mineral waters, but it is exceedingly rare.

16. Sulphate of iron occurs sometimes in volcanic mineral waters, and has even been observed in other places.

17. Sulphate of copper is only found in the waters which issue from copper mines.

18. Nitre has been found in some springs in Hungary, but it is exceedingly uncommon.

19. Nitrate of lime was first detected in water by Dr. Home, of Edinburgh, in 1756. It is said to occur in some springs in the sandy deserts of Arabia.

20. Nitrate of magnesia is said to have been found in some springs.

21. Muriate of potash is uncommon; but it has lately been discovered in the mineral springs of Uhleaborg in Sweden by Julin.

22. Muriate of soda is so extremely common in mineral waters, that hardly a single spring has been analysed without detecting some of it.

23. Muriate of ammonia is uncommon, but it has been found in some mineral springs in Italy and Siberia.

24. Muriate of barytes is still more uncommon, but its presence in mineral waters has been announced by Bergmann.

25 and 26. Muriates of lime and magnesia are common ingredients.

27. Muriate of alumina has been observed by Dr. Withering, but it is very uncommon.

28. Muriate of manganese was mentioned by Bergmann as sometimes occurring in mineral waters. It has lately been detected by Lambe in the waters of Lemington Priors, but in an extremely limited proportion.

29. The presence of carbonate of potash in mineral waters has been mentioned by several chemists; if it do occur, it must be in a very small proportion.

30. Carbonate of soda is, perhaps, one of the most common ingredients of these liquids, if we except common salt and carbonate of lime.

31. Carbonate of ammonia has been discovered in waters, but it is uncommon.

32. Carbonate of lime is found in almost all waters, and is usually held in solution by an excess of acid. It appears from the different experiments of chemists, as stated by Mr. Kirwan, and especially from those of Berthollet, that water saturated with carbonic acid is capable of holding in solution 0·002 of carbonate of lime. Now water saturated with carbonic acid, at the temperature of 50°, contains very nearly 0·002 of its weight of carbonic acid. Hence it follows that carbonic acid, when present in such quantity as to saturate waters, is capable of holding its own weight of carbonate of lime in solution. Thus we see 1000 parts by weight of water, when it contains two parts of carbonic acid, is capable of dissolving two parts of carbonate of lime. When the proportion of water is increased, it is capable of holding the carbonate of lime in solution, even when the proportion of carbonic acid united with it is diminished. Thus 24,000 parts of water are capable of holding two parts of carbonate of lime in solution, even when they contain only one part of carbonic acid. The greater the proportion of water, the smaller proportion of carbonic acid is necessary to keep the lime in solution; and when the water is increased to a certain proportion, no sensible excess of carbonic acid is necessary. It ought to be remarked also, that water, however small a quantity of carbonic acid it contains, is capable of holding carbonate of lime in solution, provided the weight of the carbonic acid present exceed

that of the lime. These observations apply equally to the other earthy carbonates held in solution by mineral waters.

33. Carbonate of magnesia is also very common in mineral waters, and is almost always accompanied by carbonate of lime.

34. Carbonate of alumina is said to have been found in waters, but its presence has not been properly ascertained.

35. Carbonate of iron is by no means uncommon; indeed it forms the most remarkable ingredient in those waters, which are distinguished by the epithet of *chalybeate.*

36. Borax exists in some lakes in Persia and Thibet, but the nature of these waters has not been ascertained.

37 and 38. The hydrosulphurets of lime and of soda have been frequently detected in those waters which are called sulphurous, or hepatic.

Mr. Westrumb says, that all sulphurous waters contain more or less hydrosulphuret of lime.

To detect this he boiled the mineral water, excluding the contact of atmospheric air, to expel the sulphuretted hydrogen gas and carbonic acid. Into the water thus boiled he poured sulphuric acid, when more sulphuretted hydrogen gas was evolved, and sulphate of lime was thrown down; fuming nitric acid, which separated from it sulphur; and oxalic acid, which expelled sulphuretted hydrogen, and formed oxalate of lime. The water evaporated in open vessels let fall sulphate of lime, and gave out sulphuretted hydrogen gas.

To ascertain the quantity of sulphuretted hydrogen gas and carbonic acid, Mr. Westrumb proceeded as follows: He introduced the sulphurous water into a matrass, till it was filled to a certain point, which he marked; fitted to it a curved tube, which terminated in a long cylinder; filled this cylinder with lime water for the one experiment, and with acetate of lead, with excess of acid, for the other; luted the apparatus; and boiled the water till no more gas was expelled. When the lime water is used, carbonate of lime is precipitated in the proportion of 20 grains to every 10 cubic inches of carbonic acid gas; when the solution of acetate of lead, hydrosulphuret of lead, is thrown down, in the proportion of 19 grains to 10 cubic inches of sulphuretted hydrogen gas.

Beside these substances, certain vegetable and animal matters have been occasionally observed in mineral waters. But in most cases these are rather to be considered in the light of accidental mixtures, than of real component parts of the waters in which they occur.

From this synoptical view of the different ingredients contained in mineral waters, it is evident that these substances occur in two different distinct states: viz. 1. as being suspended in them; and 2. as being dissolved in them chiefly in the form of a salt.

The investigation of mineral waters consists, 1. In the examination of them by the senses: 2. In the examination of them by reagents: 3. In the analysis properly so called.

The examination by the senses consists in observing the effect of the water as to appearance, smell, and taste.

The appearance of the water, the instant in which it is pumped out of the well, as well as after it has stood for some time, affords several indications, from which we are enabled to form a judgment concerning its contents. If the water be turbid at the well, the substances are suspended only, and not dissolved; but if the water be clear and transparent at the well, and some time intervenes before it becomes turbid, the contents are dissolved by means of carbonic acid.

The presence of this gas is likewise indicated by small bubbles, that rise from the bottom of the well, and burst in the air while they are making their escape, though the water at the same time perhaps has not an acid taste. This is the case, according to Count Razoumowski, with respect to the tepid spring in Vallais, and the cold vitriolated chalybeate springs at Astracan. But the most evident proof of a spring containing carbonic acid is the generation of bubbles on the water being shaken, and their bursting with more or less noise, while the air is making its escape.

The sediment deposited by the water in the well is likewise to be examined: if it be yellow, it indicates the presence of iron; if black, that of iron combined with sulphur; but chalybeate waters being seldom sulphuretted, the latter occurs very rarely. As to the colour of the water itself, there are few instances where this can give any indication of its contents, as there are not many substances that colour it.

The odour of the water serves chiefly to discover the presence of sulphuretted hydrogen in it: such waters as contain this substance have a peculiar fetid smell, somewhat resembling rotten eggs.

The taste of a spring, provided it be perfectly ascertained by repeated trials, may afford some useful indications with respect to the contents. It may be made very sensible by tasting water in which the various salts that are usually found in such waters are dissolved in various proportions. There is no certain dependence, however, to be placed on this mode of investigation; for in many springs, the taste of sulphate of soda is disguised by that of the sea salt united with it. The water too is not only to be tasted at the spring, but after it has stood for some time. This precaution must be particularly observed with respect to such waters as are impregnated with carbonic acid; for the other substances contained in them make no impression on the tongue, till the carbonic acid has made its escape; and it is for the same reason, that these waters must be evaporated in part, and then tasted again.

Though the specific gravity of any water contributes but very little towards determining its contents, still it may not be entirely useless to know the specific weight of the water, the situation of the spring, and the kind of sediment deposited by it.

The examination of the water by means of reagents shows what they contain, but not how much of each principle. In many instances this is as much as the inquiry demands; and it is always of use to direct the proceedings in the proper analysis.

It is absolutely necessary to make the experiment with water just taken up from the spring, and afterward with such as has been exposed for some hours to the open air; and sometimes a third essay is to be made with a portion of the water that has been boiled and afterward filtered. If the water contain but few saline particles, it must be evaporated; as even the most sensible reagents do not in the least affect it, if the salts, the presence of which is to be discovered by them, are diluted with too great a quantity of water. Now, it may happen, that a water shall be impregnated with a considerable number of saline particles of different kinds, though some of them may be present in too small a quantity; for which reason the water must be examined a second time, after having been boiled down to three-fourths.

The substances of which the presence is discoverable by reagents are:—

1. Carbonic acid. When this is not combined with any base, or not with sufficient to neutralize it, the addition of lime water will throw down a precipitate soluble with effervescence in muriatic acid. The infusion of litmus is reddened by it; but the red colour gradually disappears, and may be again restored by the addition of more of the mineral water. When boiled it loses the property of reddening the infusion of litmus. According to Pfaff, the most sensible test of this acid is acetate of lead.

2. The mineral acids, when present uncombined in water, give the infusion of litmus a permanent red, even though the water has been boiled. Bergmann has shown, that paper stained with litmus is reddened when dipped into water containing $\frac{1}{3821}$ of sulphuric acid.

3. Water containing sulphuretted hydrogen gas is distinguished by the following properties: It exhales the peculiar odour of sulphuretted hydrogen gas. It reddens the infusion of litmus fugaciously. It blackens paper dipped into a solution of lead, and precipitates the nitrate of silver black or brown.

4. Alkalis, and alkaline and earthy carbonates, are distinguished by the following tests: The infusion of turmeric, or paper stained with turmeric, is rendered brown by alkalis; or reddish-brown, if the quantity be minute. This change is produced when the soda is water amounts only to $\frac{1}{2377}$ part. Paper stained with brasil wood, or the infusion of brasil wood, is rendered blue; but this change is produced also by the alkaline and earthy carbonates. Bergmann ascertained, that water containing $\frac{1}{5043}$ part of carbonate of soda reddens paper stained with brasil wood blue. Litmus paper reddened by vinegar is restored to its original blue colour. This change is produced by the alkaline and earthy carbonates also. When these changes are fugacious, we may conclude, that the alkali is ammonia.

5. Fixed alkalis exist in water that occasions a precipitate with muriate of magnesia after being boiled. Volatile alkali may be distinguished by the smell; or it may be obtained in the receiver by distilling a portion of the water gently, and then it may be distinguished by the above tests.

6. Earthy and metallic carbonates are precipitated by boiling the water containing them; except carbonate of magnesia, which is precipitated but imperfectly.

7. Iron is discovered by the following tests:—The addition of tincture of galls gives water, containing iron, a purple or black colour. This test indicates the presence of a very minute portion of iron. If the tincture have no effect upon the water, after boiling, though it colours it before, the iron is in the state of a carbonate. The following observations of Westrumb on the colour which iron gives to galls, as modified by other bodies, deserve attention. A violet indicates an alkaline carbonate, or earthy salt. Dark purple indicates other alkaline salts. Purplish-red indicates sulphuretted hydrogen gas. Whitish, and then black, indicates sulphate of lime. Mr. Phillips has lately ascertained, that, while the iron is little oxided, the presence of lime rather facilitates the application of this test; but the lime prevents the test from acting, provided the iron be considerably oxidized. The prussian alkali occasions a blue precipitate in water containing iron. If an alkali be present, the blue precipitate does not appear, unless the alkali is saturated with an acid.

8. Sulphuric acid exists in waters that form a precipitate with the following solutions:—Muriate, nitrate, or acetate of barytes, strontian, or lime, or nitrate or acetate of lead. Of these the most powerful by far is muriate of barytes, which is capable of detecting the presence of sulphuric acid uncombined, when it does not exceed the millionth part of the water. Acetate of lead is next in point of power. The muriates are more powerful than the nitrates. The calcareous salts are least powerful. All these tests are capable of indicating a much smaller proportion of uncombined sulphuric acid, than when it is combined with a base. To render muriate of barytes a certain test of sulphuric acid, the following precautions must be observed;—The muriate must be diluted;

the alkalis or alkaline carbonates, if the water contain any, must be previously saturated with muriatic acid; the precipitate must be insoluble in muriatic acid; if boracic acid be suspected, muriate of strontian must be tried, which is not precipitated by boracic acid. The hydrosulphurets precipitate barytic solutions, but their presence is easily discovered by the smell.

9. Muriatic acid is detected by nitrate of silver, which occasions a white precipitate, or a cloud, in water containing an exceedingly minute portion of this acid. To render this test certain, the following precautions are necessary:—The alkalis or carbonates must be previously saturated with nitric acid. Sulphuric acid, if any be present, must be previously removed by means of nitrate of barytes. The precipitate must be insoluble in nitric acid. Pfaff says, that the mild nitrate of mercury is the most sensible test of muriatic acid; and that the precipitate is not soluble in an excess of any acid.

10. Boracic acid is detected by means of acetate of lead, with which it forms a precipitate insoluble in acetic acid. But to render this test certain, the alkalis and earths must be previously saturated with acetic acid, and the sulphuric and muriatic acids removed by means of acetate of strontian and acetate of silver.

11. Barytes is detected by the insoluble white precipitate which it forms with diluted sulphuric acid.

12. Lime is detected by means of oxalic acid, which occasions a white precipitate in water containing a very minute proportion of this earth. To render this test decisive, the following precautions are necessary:—The mineral acids, if any be present, must be previously saturated with an alkali. Barytes, if any be present, must be previously removed by means of sulphuric acid. Oxalic acid precipitates magnesia but very slowly, whereas it precipitates lime instantly.

13. Magnesia and alumina. The presence of these earths is ascertained by the following tests:—Pure ammonia precipitates them both, and no other earth, provided the carbonic acid have been previously separated by a fixed alkali and boiling. Lime water precipitates only these two earths, provided the carbonic acid be previously removed, and the sulphuric acid also, by means of nitrate of barytes.

The alumina may be separated from the magnesia, after both have been precipitated together, either by boiling the precipitate in caustic potash, which dissolves the alumina and leaves the magnesia; or the precipitate may be dissolved in muriatic acid, precipitated by an alkaline carbonate, dried in the temperature of 100°, and then exposed to the action of diluted muriatic acid, which dissolves the magnesia without touching the alumina.

14. Silex may be ascertained by evaporating a portion of water to dryness, and redissolving the precipitate in muriatic acid. The silex remains behind undissolved.

By these means we may detect the presence of the different substances commonly found in waters; but as they are generally combined so as to form salts, it is necessary we should know what these combinations are. This is a more difficult task, which Mr. Kirwan teaches us to accomplish by the following methods:—

1. To ascertain the presence of the different sulphates.

The sulphates which occur in water are seven; but one of these, namely, *sulphate of copper*, is so uncommon, that it may be excluded altogether. The same remark applies to sulphate of ammonia. It is almost unnecessary to observe, that no sulphate need be looked for, unless both its acid and base have been previously detected in the water.

Sulphate of soda may be detected by the following method:—Free the water to be examined of all earthy sulphates, by evaporating it to one-half, and adding lime water as long as any precipitate appears. By these means the earths will all be precipitated except lime, and the only remaining earthy sulphate will be sulphate of lime, which will be separated by evaporating the liquid till it becomes concentrated, and then dropping into it a little alcohol, and, after filtration, adding a little oxalic acid.

With the water thus purified, mix solution of lime. If a precipitate appear, either immediately, or on the addition of a little alcohol, it is a proof that sulphate of potash or of soda is present. Which of the two may be determined, by mixing some of the purified water with acetate of barytes. Sulphate of barytes precipitates. Filter and evaporate to dryness. Digest the residuum in alcohol. It will dissolve the alkaline acetate. Evaporate to dryness, and the dry salt will deliquesce if it be acetata of potash, but effloresce if it be acetate of soda.

Sulphate of lime may be detected by evaporating the water suspected to contain it to a few ounces. A precipitate appears, which, if it be sulphate of lime, is soluble in 500 parts of water; and the solution affords a precipitate with the muriate of barytes, oxalic acid, carbonate of magnesia, and alcohol.

Alum may be detected by mixing carbonate of lime with the water suspected to contain it. If a precipitate appear, it indicates the presence of alum, or at least of sulphate of alumina; provided the water contains no muriate of barytes or metallic sulphates. The first of these salts is incompatible with alum: the second may be removed by the alkaline prussiates. When a precipitate is produced in water by muriate of lime, carbonate of lime, and muriate of magnesia, we may conclude that it contains alum or sulphate of alumina.

Sulphate of magnesia may be detected by

means of hydrosulphuret of strontian, which occasions an immediate precipitate with this salt, and with no other; provided the water be previously deprived of alum, if any be present, by means of carbonate of lime, and provided also that it contains no uncombined acid.

Sulphate of iron is precipitated from water by alcohol, and then it may be easily recognized by its properties.

2. To ascertain the presence of the different muriates.

The muriates found in waters amount to eight, or to nine, if muriate of iron be included. The most common by far is muriate of soda.

Muriate of soda and of potash may be detected by the following method:—Separate the sulphuric acid by alcohol and nitrate of barytes. Decompose the earthy nitrates and muriates by adding sulphuric acid. Expel the excess of muriatic and nitric acids by heat. Separate the sulphates thus formed by alcohol and barytes water. The water thus purified can contain nothing but alkaline nitrates and muriates. If it form a precipitate with acetate of silver, we may conclude that it contains muriate of soda or of potash. To ascertain which, evaporate the liquid thus precipitated to dryness. Dissolve the acetate in alcohol, and again evaporate to dryness. The salt will deliquesce, if it be acetate of potash; but effloresce, if it be acetate of soda.

The potash salts are most readily distinguished by the precipitate which they afford to muriate of platinum, which the soda salts do not occasion.

Muriate of barytes may be detected by sulphuric acid, as it is the only barytic salt hitherto found in water.

Muriate of lime may be detected by the following method:—Free the water from sulphate of lime and other sulphates, by evaporating it to a few ounces, mixing it with alcohol, and adding last of all nitrate of barytes as long as any precipitate appears. Filter the water; evaporate to dryness; treat the dry mass with alcohol; evaporate the alcohol to dryness; and dissolve the residuum in water. If this solution give a precipitate with acetate of silver and oxalic acid, it may contain muriate of lime. It must contain it in that case, if, after being treated with carbonate of lime, it give no precipitate with ammonia. If the liquid in the receiver give a precipitate with nitrate of silver, muriate of lime existed in the water.

Muriate of magnesia may be detected by separating all the sulphuric acid by means of nitrate of barytes. Filter, evaporate to dryness, and treat the dry mass with alcohol. Evaporate the alcoholic solution to dryness, and dissolve the residuum in water. The muriate of magnesia, if the water contained any, will be found in this solution. Let us suppose, that, by the tests formerly described, the presence of muriatic acid and of magnesia, in this solution, has been ascertained. In that case, if carbonate of lime afford no precipitate, and if sulphuric acid and evaporation, together with the addition of a little alcohol, occasion no precipitate, the solution contains only muriate of magnesia. If these tests give precipitates, we must separate the lime which is present by sulphuric acid and alcohol, and distil off the acid with which it was combined. Then the magnesia is to be separated by the oxalic acid and alcohol, and the acid with which it was united is to be distilled off. If the liquid in the retort give a precipitate with nitrate of silver, the water contains muriate of magnesia.

Muriate of alumina may be discovered by saturating the water, if it contain an excess of alkali, with nitric acid, and by separating the sulphuric acid by means of nitrate of barytes. If the liquid, thus purified, give a precipitate with carbonate of lime, it contains muriate of alumina. The muriate of iron or of manganese, if any be present, is also decomposed, and the iron precipitated by this salt. The precipitate may be dissolved in muriatic acid, and the alumina, iron, and manganese, if they be present, may be separated by the rules laid down below.

3. To ascertain the presence of the different nitrates. The nitrates but seldom occur in waters; but when they do, they may be detected by the following results:

Alkaline nitrates may be detected by freeing the water examined from sulphuric acid by means of acetate of barytes, and from muriatic acid by acetate of silver. Evaporate the filtered liquid, and treat the dry mass with alcohol; what the alcohol leaves can consist only of the alkaline nitrates and acetate of lime. Dissolve it in water. If carbonate of magnesia occasion a precipitate, lime is present. Separate the lime by means of carbonate of magnesia. Filter and evaporate to dryness, and treat the dried mass with alcohol. The alcohol now leaves only the alkaline nitrates, which may be easily recognised, and distinguished by their respective properties.

Mr. Faraday has lately detected nitric acid in the form of a nitrate in a Cheltenham water, called the orchard well. On adding sulphuric acid to a portion of this water in quantity abundantly sufficient to decompose all the salts subject to its action, and boiling such acidulated water in a Florence flask, with a leaf of gold, for half an hour, or an hour, the gold either in part or entirely disappeared, and a solution was obtained, which, when tested by proto-muriate of tin, gave a deep purple tint. Hence, the presence of nitric acid originally in the water was inferred; and that no mistake might occur, a solution was made in pure water of all the salts except the nitrate found in the water, boiled with some of the same sulphuric acid, and tested by the same muriate of tin; but in this case no colour was afforded, or any gold dissolved. *Journal of Science*, xvii. 178.

Nitrate of lime. To detect this salt, concentrate the water, and mix it with alcohol to separate the sulphates. Filter, and distil off the alcohol; then separate the muriatic acid by acetate of silver. Filter, evaporate to dryness, and dissolve the residuum in alcohol. Evaporate to dryness, and dissolve the dry mass in water. If this last solution indicate the presence of lime by the usual tests, the water contained nitrate of lime.

To detect nitrate of magnesia, the water is to be freed from sulphates and muriates exactly as described in the last paragraph. The liquid thus purified is to be evaporated to dryness, and the residuum treated with alcohol. The alcoholic solution is to be evaporated to dryness, and the dry mass dissolved in water. To this solution potash is to be added, as long as any precipitate appears. The solution, filtered, and again evaporated to dryness, is to be treated with alcohol. If it leave a residuum consisting of nitre (the only residuum which it can leave), the water contained nitrate of magnesia.

Such are the methods by which the presence of the different saline contents of waters may be ascertained. The labour of analysis may be considerably shortened, by observing that the following salts are incompatible with each other, and cannot exist together in water, except in very minute proportion:

Salts.	Incompatible with
Fixed alkaline sulphates	Nitrates of lime and magnesia, Muriates of lime and magnesia.
Sulphate of lime	Alkalis, Carbonate of magnesia, Muriate of barytes.
Alum	Alkalis, Muriate of barytes, Nitrate, muriate, carbonate of lime, Carbonate of magnesia.
Sulphate of magnesia	Alkalis, Muriate of barytes, Nitrate and muriate of lime.
Sulphate of iron	Alkalis, Muriate of barytes, Earthy carbonates.
Muriate of barytes	Sulphates, Alkaline carbonates, Earthy carbonates.
Muriate of lime	Sulphates, except of lime, Alkaline carbonates, Earthy carbonates.
Muriate of magnesia	Alkaline carbonates, Alkaline sulphates.
Nitrate of lime	Alkaline carbonates, Carbonate of magnesia and alumina, Sulphates, except of lime.

Beside the substances above described, there is sometimes found in water a quantity of bitumen combined with alkali, and in the state of soap. In such waters acids occasion a coagulation; and the coagulum collected on a filter discovers its bitumous nature by its combustibility.

Water also sometimes contains extractive matter; the presence of which may be detected by means of nitrate of silver. The water suspected to contain it must be freed from sulphuric and nitric acid by means of nitrate of lead; after this, if it give a brown precipitate with nitrate of silver, we may conclude that extractive matter is present.

But it is not sufficient to know that a mineral water contains certain ingredients; it is necessary to ascertain the proportions of these, and thus we arrive at their complete analysis.

1. The different aërial fluids ought to be first separated and estimated. For this purpose, a retort should be filled two-thirds with the water, and connected with a jar full of mercury, standing over a mercurial trough. Let the water be made to boil for a quarter of an hour. The aërial fluids will pass over into the jar. When the apparatus is cool, the quantity of air expelled from the water may be determined either by bringing the mercury within and without the jar to a level; or if this cannot be done, by reducing the air to the proper density by calculation. The air of the retort ought to be carefully subtracted, and the jar should be divided into cubic inches and tenths.

The only gaseous bodies contained in water are, common air, oxygen gas, nitrogen gas, carbonic acid, sulphuretted hydrogen gas, and sulphurous acid. The last two never exist in water together. The presence of either of them must be ascertained previously by the application of the proper tests. If sulphuretted hydrogen gas be present, it will be mixed with the air contained in the glass jar, and must be separated before this air be examined. For this purpose the jar must be removed into a tub of warm water, and nitric acid introduced, which will absorb the sulphuretted hydrogen. The residuum is then to be again put into a mercurial jar, and examined.

If the water contain sulphurous acid, this previous step is not necessary. Introduce into the air a solution of pure potash, and agitate the whole gently. The carbonic acid and sulphurous acid gas will be absorbed, and leave the other gases. The bulk of this residuum, subtracted from the bulk of the whole, will give the bulk of the carbonic acid and sulphurous acid absorbed.

Evaporate the potash slowly, almost to dryness, and leave it exposed to the atmosphere. Sulphate of potash will be formed, which may be separated by dissolving the carbonate of potash by means of diluted muriatic acid, and filtering the solution. 100 grains of sulphate of potash indicate 36·4 grains of sulphurous acid, or 53·66 cubic inches of that acid in the state of gas. The bulk of sulphurous acid gas ascertained by this method, subtracted from the bulk of the gas absorbed by the potash, gives the bulk of the carbonic acid gas. Now 100 cubic inches of carbonic acid, at the temperature of 60° and barometer 30 inches, weigh 46·6 grains. Hence it is easy to ascertain its weight.

The gas remaining may be examined by the common eudiometrical processes.

When a water contains sulphuretted hydrogen gas, the bulk of this gas is to be ascertained in the following manner: Fill three-fourths of a jar with the water to be examined, and invert it in a water trough, and introduce a little nitrous gas. This gas, mixing with the air in the upper part of the jar, will form nitrous acid, which will render the water turbid, by decomposing the sulphuretted hydrogen, and precipitating sulphur. Continue to add nitrous gas at intervals as long as red fumes appear, then turn up the jar and blow out the air. If the hepatic smell continue, repeat this process. The sulphur precipitated indicates the proportion of hepatic gas in the water; one grain of sulphur indicating the presence of nearly 3 cubic inches of this gas.

2. After having estimated the gaseous bodies, the next step is to ascertain the proportion of the earthy carbonates. For this purpose it is necessary to deprive the water of its sulphuretted hydrogen, if it contain any. This may be done, either by exposing it to the air for a considerable time, or treating it with litharge. A sufficient quantity of the water, thus purified if necessary, is to be boiled for a quarter of an hour, and filtered when cool. The earthy carbonates remain on the filter.

The precipitate thus obtained may be carbonate of lime, of magnesia, of iron, of alumina, or even sulphate of lime. Let us suppose all of these substances to be present together. Treat the mixture with diluted muriatic acid, which will dissolve the whole except the alumina and sulphate of lime. Dry this residuum in a red heat, and note the weight. Then boil it in carbonate of soda, saturate the soda with muriatic acid, and boil the mixture for half an hour. Carbonate of lime and alumina precipitate. Dry this precipitate, and treat it with acetic acid. The lime will be dissolved, and the alumina will remain. Dry it and weigh it. Its weight, subtracted from the original weight, gives the proportion of sulphate of lime.

The muriatic solution contains lime, magnesia, and iron. Add ammonia as long as a reddish precipitate appears. The iron and part of the magnesia are thus separated. Dry the precipitate, and expose it to the air for some time in a heat of 200°; then treat it with acetic acid to dissolve the magnesia; which solution is to be added to the muriatic solution. The iron is to be redissolved in muriatic acid, precipitated by an alkaline carbonate, dried and weighed.

Add sulphuric acid to the muriatic solution as long as any precipitate appears; then heat the solution and concentrate. Heat the sulphate of lime thus obtained to redness, and weigh it. 100 grains of it are equivalent to 74·7 of carbonate of lime dried. Precipitate the magnesia by means of carbonate of soda. Dry it and weigh it. But as part remains in solution, evaporate to dryness, and wash the residuum with a sufficient quantity of distilled water, to dissolve the muriate of soda and sulphate of lime, if any be still present. What remains behind is carbonate of magnesia. Weigh it, and add its weight to the former. The sulphate of lime, if any, must also be separated and weighed.

3. We have next to ascertain the proportion of mineral acids or alkalis, if any be present uncombined. The acids which may be present, omitting the gaseous, are the sulphuric, muriatic, and boracic.

The proportion of sulphuric acid is easily determined. Saturate it with barytes water, and ignite the precipitate. 100 grains of sulphate of barytes thus formed, indicate 34·0 of real sulphuric acid.

Saturate the muriatic acid with barytes water, and then precipitate the barytes by sulphuric acid. 100 parts of the ignited precipitate are equivalent to 23·73 grains of real muriatic acid.

Precipitate the boracic acid by means of acetate of lead. Decompose the borate of lead by boiling it in sulphuric acid. Evaporate to dryness. Dissolve the boracic acid in alcohol, and evaporate the solution; the acid left behind may be weighed.

To estimate the proportion of alkaline carbonate present in a water containing it, saturate it with sulphuric acid, and note the weight of real acid necessary. Now 100 grains of real sulphuric acid saturate 120·0 potash, and 80·0 soda.

4. The alkaline sulphates may be estimated by precipitating their acid by means of nitrate of barytes, having previously freed the water from all other sulphates; for 14·75 grains of ignited sulphate of barytes indicate 9·0 grains of dried sulphate of soda; while 14·75 sulphate of barytes indicate 11 of dry sulphate of potash.

Sulphate of lime is easily estimated by evaporating the liquid containing it to a few ounces (having previously saturated the earthy carbonates with nitric acid), and precipitating the sulphate of lime by means of weak alcohol. It may then be dried and weighed.

The quantity of alum may be estimated by precipitating the alumina by carbonate of lime or of magnesia, (if no lime be present in the liquid). Eleven grains of the alumina, heated to incandescence, indicate 100 of crystallized alum, or 55 of dried salt.

Sulphate of magnesia may be estimated,

provided no other sulphate be present, by precipitating the acid by means of a barytic salt, as 14·75 parts of ignited sulphate of barytes indicate 7·5 of sulphate of magnesia. If sulphate of lime, and no other sulphate, accompany it, this may be decomposed, and the lime precipitated by carbonate of magnesia. The weight of the lime thus obtained enables us to ascertain the quantity of sulphate of lime contained in the water. The whole of the sulphuric acid is then to be precipitated by barytes. This gives the quantity of sulphuric acid; and subtracting the portion which belongs to the sulphate of lime, there remains that which was combined with the magnesia, from which the sulphate of magnesia may be easily estimated.

If sulphate of soda be present, no earthy nitrate or muriate can exist. Therefore, if no other earthy sulphate be present, the magnesia may be precipitated by soda, dried and weighed; 2·5 grains of which indicate 7·5 grains of dried sulphate of magnesia. The same process succeeds when sulphate of lime accompanies these two sulphates; only in this case the precipitate, which consists both of lime and magnesia, is to be dissolved in sulphuric acid evaporated to dryness, and treated with twice its weight of cold water, which dissolves the sulphate of magnesia, and leaves the other salt. Let the sulphate of magnesia be evaporated to dryness, exposed to a heat of 400°, and weighed. The same process succeeds, if alum be present instead of sulphate of lime. The precipitate in this case, previously dried, is to be treated with acetic acid, which dissolves the magnesia, and leaves the alumina. The magnesia may be again precipitated, dried, and weighed. If sulphate of iron be present, it may be separated by exposing the water to the air for some days, and mixing with it a portion of alumina. Both the oxide of iron and the sulphate of alumina, thus formed, precipitate in the state of an insoluble powder. The sulphate of magnesia may then be estimated by the rules above given.

Sulphate of iron may be estimated by precipitating the iron by means of prussic alkali, having previously determined the weight of the precipitate produced by the prussiate in a solution of a given weight of sulphate of iron in water. If muriate of iron be also present, which is a very rare case, it may be separated by evaporating the water to dryness, and treating the residuum with alcohol, which dissolves the muriate, and leaves the sulphate.

5. If muriate of potash, or of soda, without any other salt, exist in water, we have only to decompose them by nitrate of silver, and dry the precipitate; for 18·25 of muriate of silver indicate 9·5 of muriate of potash; and 18·25 of muriate of silver indicate 7·5 of common salt.

The same process is to be followed, if the alkaline carbonates be present; only these carbonates must be previously saturated with sulphuric acid; and we must precipitate the muriatic acid by means of sulphate of silver instead of nitrate. The presence of sulphate of soda does not injure the success of this process.

If muriate of ammonia accompany either of the fixed alkaline sulphates, without the presence of any other salt; decompose the sal ammoniac by barytes water, expel the ammonia by boiling, precipitate the barytes by diluted sulphuric acid, and saturate the muriatic acid with soda. The sulphate of barytes thus precipitated indicates the quantity of muriate of ammonia, 14·75 grains of sulphate indicating 6·75 grains of this salt. If any sulphates be present in the solution, they ought to be previously separated.

If common salt be accompanied by muriate of lime, muriate of magnesia, muriate of alumina, or muriate of iron, or by all these together, without any other salt, the earths may be precipitated by barytes water, and redissolved in muriatic acid. They are then to be separated from each other by the rules formerly laid down, and their weight, being determined, indicates the quantity of every particular earthy muriate contained in the water. For 50 grains of lime indicate 100 of dried muriate of lime; 30 grains of magnesia indicate 100 of the muriate of that earth; and 21·8 grains of alumina indicate 100 of the muriate of alumina. The barytes is to be separated from the solution by sulphuric acid, and the muriatic acid expelled by heat, or saturated with soda; the common salt may then be ascertained by evaporation, subtracting in the last case the proportion of common salt indicated by the known quantity of muriatic acid from which the earths had been separated.

When sulphates and muriates exist together, they ought to be separated either by precipitating the sulphates by means of alcohol, or by evaporating the whole to dryness, and dissolving the earthy muriates in alcohol. The salts thus separated may be estimated by the rules already laid down.

When alkaline and earthy muriates and sulphate of lime occur together, the last is to be decomposed by means of muriate of barytes. The precipitate ascertains the weight of sulphate of lime contained in the water. The estimation is then to be conducted as when nothing but muriates are present, only from the muriate of lime that proportion of muriate must be deducted which is known to have been formed by the addition of the muriate of barytes.

When muriates of soda, magnesia, and alumina are present together with sulphates of lime and magnesia, the water to be examined ought to be divided into two equal portions. To the one portion add carbonate of magnesia till the whole of the lime and alumina is precipitated. Ascertain the quantity of lime which gives the proportion of sulphate of lime. Precipitate the sulphuric acid by muriate of barytes. This gives the quantity contained in the sulphate of magnesia and sulphate of lime: subtracting this last portion, we have the quantity of sulphate of magnesia.

From the second portion of water, precipitate all the magnesia and alumina by means of lime water. The weight of these earths enables us to ascertain the weight of muriate of magnesia and of alumina contained in the water, subtracting that part of the magnesia which existed in the state of sulphate, as indicated by the examination of the first portion of water. After this estimation, precipitate the sulphuric acid by barytes water, and the lime by carbonic acid. The liquid, evaporated to dryness, leaves the common salt.

6. It now only remains to explain the method of ascertaining the proportion of the nitrates which may exist in waters.

When nitre accompanies sulphates and muriates without any other nitrates, the sulphates are to be decomposed by acetate of barytes, and the muriates by acetate of silver. The water, after filtration, is to be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetates, and leaves the nitre, the quantity of which may be easily calculated. If an alkali be present, it ought to be previously saturated with sulphuric or muriatic acid.

If nitre, common salt, nitrate of lime, and muriate of lime or magnesia, be present together, the water ought to be evaporated to dryness, and the dry mass treated with alcohol, which takes up the earthy salts. From the residuum, redissolved in water, the nitre may be separated, and calculated as in the last case. The alcoholic solution is to be evaporated to dryness, and the residuum redissolved in water. Let us suppose it to contain muriate of magnesia, nitrate of lime, and muriate of lime. Precipitate the muriatic acid by nitrate of silver, which gives the proportion of muriate of magnesia and of lime. Separate the magnesia by means of carbonate of lime, and note its quantity. This gives the quantity of muriate of magnesia; and subtracting the muriatic acid contained in that salt from the whole acid indicated by the precipitate of silver, we have the proportion of muriate of lime. Lastly, saturate the lime added to precipitate the magnesia with nitric acid. Then precipitate the whole of the lime by sulphuric acid; and subtracting from the whole of the sulphate thus formed that portion formed by the carbonate of lime added, and by the lime contained in the muriate, the residuum gives us the lime contained in the original nitrate; and 35 grains of lime form 102·5 of dry nitrate of lime.

In the year 1807, Dr. Marcet advanced some new ideas on the art of analyzing mineral waters, in an admirable paper on the water of the Dead Sea, inserted in the Phil. Transactions. "It is satisfactory to observe," says this excellent chemist, "that Dr. Murray adopted, several years afterwards, a mode of proceeding precisely similar, and indeed that he proposed, in a subsequent paper, a general formula for the analysis of mineral waters, in which this method is pointed out, as likely to lead to the most accurate results. And this coincidence is the more remarkable, as it would appear from Dr. Murray not mentioning my labours, that they had not at that time come to his knowledge." *Phil. Trans.* 1819, part ii.

The following table exhibits the compositions of the principal mineral waters as well as that of the sea. The reader will find in the Phil. Trans. for 1819 a very valuable dissertation on sea-water, by Dr. Marcet, of which a good abstract is given in the 2d volume of the Edin. Phil. Journal. This philosopher shows that in Baffin's-Bay, the Mediterranean Sea, and the Tropical Seas, the *temperature* of the sea *diminishes* with the depth, according to the observations of Phipps, Ross, Parry, Sabine, Saussure, Ellis, and Peron; but that in the Arctic or Greenland Seas, the *temperature* of the sea *increases* with the depth. This singular result was first obtained by Mr. Scoresby, in a series of well-conducted experiments, and has been confirmed by the later observations of Lieutenants Franklin and Beechy, and Mr. Fisher.

I shall prefix the results of the recent analysis by M. Berzelius of the waters of Carlsbad. They are very extraordinary, and he has found many substances not hitherto suspected to exist in them.

Sulphate of soda	2·58714
Carbonate of soda	1·25200
Muriate of soda	1·04893
Carbonate of lime	0·31219
Fluate of lime	0·00331
Phosphate of lime	0·00019
Carbonate of strontites	0·00097
Carbonate of magnesia	0·18221
Phosphate of alumina	0·00034
Carbonate of iron	0·00424
Carbonate of manganese	a trace
Silica	0.07504
	5·46656

Ann. de Chim. et Phys. xxi. 248.

	Names of the Springs.	Grains of water.	Cubic inches of gases.				Carbonates of				Sulphates of				Muriates of				Silica.	Alumina.	Resins.	Temperature.
			Oxygen.	Carbonic acid.	Sulph. hydrogen.	Asote.	Soda. gr.	Lime. gr.	Magnesia. gr.	Iron. gr.	Soda. gr.	Lime gr.	Magnesia. gr.	Iron. gr.	Soda. gr.	Lime. gr.	Magnesia. gr.	Potash. gr.	gr.	gr.	gr.	
Acidulous.	Seltzer (1)	8949	48.5	13.068			5.22	78.3	6.32						13.74							cold
	Pyrmont (1)	8950		19.6				4.3	9.8	0.70		8 88	5.44		1.7							cold
	Spa (1)	8933		9.5			1.85	1.85	4.35	0.70					0.21							cold
	Carlsbad (2)	25820		50.0			38.5	12.5		0.1½	66.75				32.5				2.25			165°
	Kilburn (10)	138240		84.0	36.0			2.4	1.25	0.2¼	18.2	13 0	91.0		6.0	0.6	2.8				6.0	cold
Sulphurous.	Harrowgate (14)	103643		8.0	19.0	7.0		18.5	5.5				0.5		615.5	3.0	9.1					cold
	Moffat (14)	103643		1.0	10.0	4.0									3.6							cold
	Aix-la-Chapelle (3)	8940			13.06			15.25	5.89						6.21							143°
	Enghein (5)	92160		18.5	7.0			21.4	1.35			33.3	5.8		2.4		8.0					cold
Saline.	Sedlits	58309		8.0				6.7	21.0			41.1	1444				36.5					cold
	Cheltenham (6)	103643		30.3	3.0	12.0			12.5	5.0	48.0	40.			5.0		12.5					cold
	Plombieres (20)	14600					36.	0.4			1.0				2.0							cold
	Dunblane (16) sp. gr. 1.00475	7291						0.5		0.17	3.7				21.	23.8						cold
	Pitcaithley (16)	7291		1.				0.5			0.9				12.7	20.2						cold
Chalybeate.	Tunbridge (8)	103643	1.4	10.6		4.0				1.0		1.25			0.5		2.25					cold
	Brighton (4)	58309		18.0								32.7		11.2	12.2		6.0		1.12			cold
	Toplitz (7)	22540					13.5	16.5		22.5					61.3	28.5				15.1		cold
Calcareous, nearly pure.	Bath (8)	15360		2.4				1.6		0.004	3.0	18.0			6.6				0.4			114°
	Buxton (9)	58300				2.0		10.5				2.5			1.5							82°
	Bristol (11)	58309		30.3				13.5			11.2	11.7			4.0		7.25					74°
	Matlock	58309										trace										66°
	Malvern (15)	58309					5.33	1.6	0.92	0.625	2.896				1.55							cold
	Dead Sea (17) sp. gr. 1.211	100										.054			10.676	3.8	10.1					
	Do. (18) sp. gr. 1.245														7.8	10.6	24.2					
	Do. (19) sp. gr. 1.2283														6.95	4.0	15.31					
	Sea water, Forth (16)	7291									25.6				159.3	5.7	25.5	trace +				

(1) Bergmann. (2) Klaproth. (3) Babington. (4) Marcet. (5) Fourcroy. (6) Fothergill. (7) John.
(8) Phillips. (9) Pearson. (10) Schmeisser. (11) Carrick. (14) Garnet. (15) Dr. Philip. (16) Dr. Murray.
(17) Dr. Marcet. (18) Klaproth. (19) M. Gay Lussac. (20) Vauquelin. + Dr. Wollaston.

R (OXYGENIZED), or deut-
ydrogen. This interesting com-
been lately formed by M. Thenard,
ount of it published in the tenth
he Annales de Chimie et de Phy-
e deutoxide of barium being dis-
water, and sulphuric acid added,
de of barium or barytes falls down,
oxygen combined with the water.
at 32° F. when saturated, twice
of oxygen of common water; that
ubic inch absorbs 662 cubic inches
gr. forming 476·98 grains, and ac-
cific gravity of 1·453. Hence 1·0
becomes apparently 1·3; contain-
volumes of oxygen; and 1 volume
ntains very nearly 1000 volumes.
quence of this great density, when
into common water, we see it fall
gh that liquid like a sort of syrup,
very soluble in it. It attacks the
almost instantly, and produces a
ain, the duration of which varies,
o the quantity of the liquid ap-
e skin. If this quantity be too
the liquid be renewed, the skin
acked and destroyed. When ap-
tongue, it whitens it also, thickens
nd produces in the organs of taste
difficult to express, but one which
to that of tartar emetic. Its ac-
de of silver is exceedingly violent.
of the liquid let fall on the dry
ces a real explosion; and so much
ved, that if the experiment be made
lace, there is a very sensible disen-
f light. Besides the oxide of silver,
veral other oxides, which act with
oxygenated water; for example,
e of manganese, that of cobalt, the
ad, platinum, gold, iridium, rho-
adium. Several metals in a state
division occasion the same pheno-
ch as silver, platinum, gold, os-
ium, rhodium, palladium. In all
ng cases, it is always the oxygen
he water which is disengaged, and
likewise that of the oxide; but in
ortion of the oxygen unites with
self. This is the case when arsenic,
m, tungsten, or selenium is em-
ese metals are often acidified with
ion of light.

s render the oxygenated water more
ld in a state of extreme division
great force on pure oxygenated
it has no action on that liquid, if
with a little sulphuric acid.

ard took pure oxygenated water,
it, so that it contained only 8 times
f oxygen. He passed 22 measures
tube filled with mercury. He then
little fibrin, quite white, and re-
cted from blood. The oxygen
ntly to be disengaged from the
water; the mercury in the tube sunk; at the end of six minutes the water was completely disoxygenated; for it no longer effervesced with oxide of silver. Having then measured the gas disengaged, he found it, 176 measures = 8 × 22, that is to say, as much as the liquid contained. This gas contained neither carbonic acid nor azote. It was pure oxygen. The same fibrin placed in contact with new portions of oxygenated water, acted in the same manner.

Urea, albumen, liquid or solid, and gelatin, do not disengage oxygen from water, even very much oxygenated. But the tissue of the lungs cut into thin slices, and well washed; that of the kidneys and the spleen, drive the oxygen out of the water, with as much facility, at least, as fibrin does. The skin and the veins possess the same property, but in a weaker degree. These results are equally interesting and mysterious. For a valuable application of oxygenated water, see PAINTS.

WAVELITE. Colour grayish-white. Imitative and crystallized, in very oblique four-sided prisms, flatly bevelled on the extremities, or truncated on the obtuse lateral edges. Shining, pearly. Fragments wedge-shaped. Translucent. As hard as fluor spar. Brittle. Sp. gr. 2·3 to 2·8. Its constituents are, alumina 70, lime 1·4, water 26·2.—*Davy.* It is said to contain also a small quantity of fluoric acid. It occurs in veins along with fluor spar, quartz, tinstone, and copper pyrites in granite, at St. Austle in Cornwall. At Barnstaple in Devonshire, where it was first found by Dr. Wavell, it traverses slate-clay, in the form of small contemporaneous veins. It has been found in rocks of slate-clay, near Loch Humphrey, Dumbartonshire.

WAX is an oily concrete matter gathered by bees from plants. Proust says, that the bloom on fruit is real wax; and that it is wax spread over leaves, which prevents them from being wetted, as on the cabbage-leaf. He likewise finds it in the fecula of some vegetables, particularly in that of the small house-leek, in which it abounds. Huber, however, asserts, from his observations, that the wax in bee-hives is an artificial production, made by the bees from honey; that they cannot procure it, unless they have honey or sugar for the purpose; and that raw sugar affords more than honey.

It was long considered as a resin, from some properties common to it with resins. Like them, it furnishes an oil and an acid by distillation, and is soluble in all oils; but in several respects it differs sensibly from resins. Like these, wax has not a strong aromatic taste and smell, but a very weak smell, and when pure, no taste. With the heat of boiling water no principles are distilled from it; whereas, with that heat, some essential oil, or at least a spirituous rector, is obtained from every resin. Farther, wax is less soluble in alcohol. If wax be distilled with a heat greater than that of boiling water, it may be decomposed, but not so easily as resins can. By this distillation, a small quantity of water is first separated from the wax, and then some very volatile and very penetrating acid, accompanied with a small quantity of a very fluid and very odoriferous oil. As the distillation advances, the acid becomes more and more strong, and the oil more and more thick, till its consistence is such that it becomes solid in the receiver, and is then called butter of wax. When the distillation is finished, nothing remains but a small quantity of coal, which is almost incombustible.

Wax cannot be kindled, unless it is previously heated and reduced into vapours; in which respect it resembles fat oils. The oil of butter of wax may by repeated distillations be attenuated and rendered more and more fluid, because some portion of acid is thereby separated from these substances; which effect is similar to what happens in the distillation of other oils and oily concretes: but this remarkable effect attends the repeated distillation of oil and butter of wax, that they become more and more soluble in alcohol; and that they never acquire greater consistence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glass vessel open, or carelessly closed, during twenty years, without acquiring a more solid consistence. It may be remarked, that wax, its butter, and its oil, differ entirely from essential oils and resins in all the above mentioned properties, and that in all these they perfectly resemble sweet oils. Hence Macquer concludes, that wax resembles resins only in being an oil rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which in resins is of the nature of essential oils, while in wax and in other analogous oily concretions (as butter of milk, butter of cocoa, fat of animals, spermaceti, and myrtle-wax), it is of the nature of mild, unctuous oils, that are not aromatic, and not volatile, and are obtained from vegetables by expression.

It seems probable, that the acidifying principle, or oxygen, and not an actual acid, may be the leading cause of the solidity, or low fusibility of wax. Wax is very useful, especially as a better material than any other for candles.

Wax may be deprived of its natural yellow disagreeble colour, and be perfectly whitened, by exposure to the united action of air and water, by which method the colour of many substances may be destroyed.

The art of bleaching wax consists in increasing its surface; for which purpose it must be melted with a degree of heat not sufficient to alter its quality, in a caldron so disposed, that the melted wax may flow gradually through a pipe at the bottom of the caldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribands. The continual rotation of the cylinder carries off these ribands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribands thus placed upon the frames ought not to exceed an inch and a half, and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favourable, the colour will be changed in the space of some days. It is then to be re-melted and formed into ribands, and exposed to the action of the air as before. These operations are to be repeated till the wax is rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

Wax is composed, according to MM. Gay Lussac and Thenard, of

Oxygen,	5·544
Hydrogen,	12·672
Carbon,	81·784
	100·000

See CERIN.

By my analysis wax consists in 100 parts of,

Carbon,	80·69	13 atoms	9·75	80·4
Hydrogen,	11·37	11	1·375	11·3
Oxygen,	7·94	1	1·000	8·3
	100·00			100·0

Or in other words, of 11 atoms olefiant gas + 1 atom carbonic oxide + 1 atom carbon. Had the experiment given a very little more hydrogen, we should have had wax as consisting of 12 atoms olefiant gas + 1 atom carbonic oxide. *Phil. Trans.* for 1822.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emolient, and relaxing remedy: but it is only used externally, mixed with other substances.

WELD, OR WOALD (reseda luteola, Linn.), is a plant cultivated in Kent, Herefordshire, and many other parts of this kingdom. The whole of the plant is used for dyeing yellow; though some assert, that the seeds only afford the colouring matter.

Two sorts of Weld are distinguished: the bastard or wild, which grows naturally in the fields; and the cultivated, the stalks of which are smaller, and not so high. For dyeing, the latter is preferred, it abounding more in colouring matter. The more slender the stalk, the more it is valued.

When the weld is ripe, it is pulled, dried, and made into bundles, in which state it is used.

The yellow communicated to wool by weld has little permanency, if the wool be not previously prepared by some mordant. For this purpose alum and tartar are used, by means of which this plant gives a very pure yellow, which has the advantage of being permanent.

For the boiling, which is conducted in the common way, Hellot directs four ounces of alum to every pound of wool, and only one ounce of tartar: many dyers, however, use half as much tartar as alum. Tartar renders the colour paler, but more lively.

For the welding, that is, for the dyeing with weld, the plant is boiled in a fresh bath, enclosing it in a bag of thin linen, and keeping it from rising to the top by means of a heavy wooden cross. Some dyers boil it till it sinks to the bottom of the copper, and then let a cross down upon it: others, when it is boiled, take it out with a rake and throw it away.

Hellot directs five or six pounds of weld for every pound of cloth; but dyers seldom use so much, contenting themselves with three or four pounds, or even much less.

To dye silk plain yellow, in general no other ingredient than weld is used. The silk ought to be scoured in the proportion of twenty pounds of soap to the hundred, and afterward alumed and refreshed, that is, washed after the aluming.

A bath is prepared with two pounds of weld for each pound of silk, which, after a quarter of an hour's boiling, is to be passed through a sieve or cloth into a vat: when it is of such a temperature as the hand can bear, the silk is put in, and turned till the colour is become uniform: during this operation the weld is boiled a second time in fresh water; about half of the first bath is taken out, and its place supplied by a fresh decoction. This fresh bath may be used a little hotter than the former; too great a degree of heat, however, must be avoided, that no part of the colour already fixed may be dissolved: it is to be turned as before, and in the mean time a quantity of the ashes of wineless is to be dissolved in a part of the second decoction; the silk is to be taken out of the bath, that more or less of this solution may be put in, according to the shade required. After it has been turned a few times, a hank is wrung with the pin, that it may be seen whether the colour be sufficiently full, and have the proper gold cast; if it should not, a little more of the alkaline solution is added, the effect of which is to give the colour a gold cast, and to render it deeper. In this way the process is to be continued, until the silk has attained the desired shade; the alkaline solution may also be added along with the second decoction of the weld, always taking care that the bath is not too hot.

If we wish to produce yellows with more of a gold or jonquille colour, a quantity of anotta proportioned to the shade required must be added to the bath along with the alkali.

A water-colour, called weld-yellow, is much used by paper-hanging manufacturers. This is the colouring matter of weld precipitated with an earthy base. The following is given in the Philosophical Magazine as a method of preparing it very fine:—Into a copper vessel put four pounds of fine washed whiting and as much soft water, and boil them together, stirring them with a deal stick, till the whole forms a smooth mixture: then add gradually twelve ounces of powdered alum, still stirring, till the effervescence ceases, and the whole is well mixed. Into another copper put any quantity of weld, with the roots uppermost; pour in soft water enough to cover every part containing seed; let it boil, but not more than a quarter of an hour; take out the weld, and set it to drain; and pass the whole of the liquor through flannel. To the hot mixture of earth and water add as much of this decoction as will produce a good colour; keep it on the fire till it boils, and then pour out into a deal or earthen vessel. The next day the liquor may be decanted, and the colour dried on chalk.

WELTER'S TUBE. See Laboratory.

WERNERITE. *Foliated Scapolite.*

WHEAT FLOUR. See Gluten and Zimome.

WHEAT. See Bread, Gluten, Starch.

WHET SLATE. Colour greenish-gray. Massive. Feebly glimmering. Fracture slaty in the large; splintery in the small. Fragments tabular. Translucent on the edges. Streak grayish-white. Soft in a low degree. Feels rather greasy. Sp. gr. 2.722. It occurs in beds in primitive and transition clay-slate. It is found at Seifersdorf near Freyberg. Very fine varieties are brought from Turkey, called Honestones. It is used for sharpening steel instruments.

WHEY. The fluid part of milk which remains after the curd has been separated. See Milk. It contains a saccharine matter, some butter, and a small portion of cheese.

WHISKY. Dilute *Alcohol*, which see, and Distillation.

WHITE COPPER. See Tutenag.

WHITE, SPANISH, and WHITE LEAD. See Ceruse.

WHITING. Chalk cleared of its grosser impurities, then ground in a mill, and made up into small loaves, is sold under the name of Whiting.

WINE. Chemists give the name of wine in general to all liquors that have become spirituous by fermentation. Thus cider, beer, hydromel or mead, and other similar liquors, are wines.

The principles and theory of the fermentation which produces these liquors are essentially the same. The more general principles we have explained under the article FERMENTATION.

All those nutritive, vegetable, and animal matters which contain sugar ready formed, are susceptible of the spirituous fermentation. Thus wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugiverous animals; and lastly, it may be made of all ripe succulent fruits: but all these substances are not equally proper to be changed into a good and generous wine.

As the production of alcohol is the result of the spirituous fermentation, that wine may be considered as essentially the best, which contains most alcohol. But of all substances susceptible of the spirituous fermentation, none is capable of being converted into so good wine, as the juice of the grapes of France, or of other countries that are nearly in the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines that have a more agreeable, that is, more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France: at least from these latter wines the best vinegar and brandy are made. As an example, therefore, of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France.

This juice, when newly expressed, and before it has begun to ferment, is called must, and in common language sweet wine. It is turbid, has an agreeable and very saccharine taste. It is very laxative; and when drunk too freely, or by persons disposed to diarrhœas, it is apt to occasion these disorders. Its consistence is somewhat less fluid than that of water, and it becomes almost of a pitchy thickness when dried.

When the must is pressed from the grapes, and put into a proper vessel and place, with a temperature between fifty-five and sixty degrees, very sensible effects are produced in it, in a shorter or longer time, according to the nature of the liquor, and the exposure of the place. It then swells, and is so rarefied, that it frequently overflows the vessel containing it, if this be nearly full. An intestine motion is excited among its parts, accompanied with a small hissing noise and evident ebullition. The bubbles rise to the surface, and at the same time is disengaged a quantity of carbonic acid of such purity, and so subtle and dangerous, that it is capable of killing instantly men and animals exposed to it in a place where the air is not renewed. The skins, stones, and other grosser matters of the grapes, are buoyed up by the particles of disengaged air that adhere to their surface, are variously agitated, and are raised in form of a scum, or soft and spongy crust, that covers the whole liquor. During the fermentation, this crust is frequently raised, and broken by the air disengaged from the liquor which forces its way through it; afterward the crust subsides, and becomes entire as before.

These effects continue while the fermentation is brisk, and at last gradually cease: then the crust, being no longer supported, falls in pieces to the bottom of the liquor. At this time, if we would have a strong and generous wine, all sensible fermentation must be stopped. This is done by putting the wine into close vessels, and carrying these into a cellar or other cool place.

After this first operation, an interval of repose takes place, as is indicated by the cessation of the sensible effects of the spirituous fermentation; and thus enables us to preserve a liquor no less agreeable in its taste, than useful for its reviving and nutritive qualities when drunk moderately.

If we examine the wine produced by this first fermentation, we shall find, that it differs entirely and essentially from the juice of grapes before fermentation. Its sweet and saccharine taste is changed into one that is very different, though still agreeable, and somewhat spirituous and piquant. It has not the laxative quality of must, but affects the head, and occasions, as is well known, drunkenness. Lastly, if it be distilled, it yields, instead of the insipid water obtained from must by distillation with the heat of boiling water, a volatile, spirituous, and inflammable liquor called spirit of wine, or alcohol. This spirit is consequently a new being, produced by the kind of fermentation called the vinous or spirituous. See ALCOHOL.

When any liquor undergoes the spirituous fermentation, all its parts seem not to ferment at the same time, otherwise the fermentation would probably be very quickly completed, and the appearances would be much more striking: hence, in a liquor much disposed to fermentation, this motion is more quick and simultaneous than in another liquor less disposed. Experience has shown, that a wine the fermentation of which is very slow and tedious, is never good or very spirituous; and therefore, when the weather is too cold, the fermentation is usually accelerated by heating the place in which the wine is made. A proposal has been made by a person very intelligent in economical affairs, to apply a greater than the usual heat to accelerate the fermentation of the wine, in those years in which grapes have not been sufficiently ripened, and when the juice is not sufficiently disposed to fermentation.

A too hasty and violent fermentation is perhaps also hurtful, from the dissipation and loss of some of the spirit; but of this we are not certain. However, we may distinguish, in the ordinary method of making wines of grapes, two periods in the fermentation, the first of which lasts during the appearance of the sensible effects above mentioned, in which the greatest number of fermentable particles ferment. After this first effort of fermentation, these effects sensibly diminish, and ought to be stopped, for reasons hereafter to be mentioned. The fermentative motion of the liquors then ceases. The heterogeneous parts that were suspended in the wines by this motion, and render it muddy, are separated and form a sediment called the lees; after which the wine becomes clear: but though the operation is then considered as finished, and the fermentation apparently ceases, it does not really cease; and it ought to be continued in some degree, if we would have good wine.

In this new wine a part of the liquor probably remains, that has not fermented, and which afterward ferments, but so very slowly, that none of the sensible effects produced in the first fermentation are here perceived. The fermentation therefore still continues in the wine, during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation, which may be called the imperceptible fermentation. We may easily perceive, that the effect of this imperceptible fermentation is the gradual increase of the quantity of alcohol. It has also another effect no less advantageous, namely, the separation of the acid salt called tartar from the wine. This matter is therefore a second sediment, that is formed in the wine, and adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it is evident that the wine, which by means of the insensible fermentation has acquired more alcohol, and has disengaged itself of the greater part of its tartar, ought to be much better and more agreeable; and for this reason chiefly, old wine is universally preferable to new wine.

But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation have regularly proceeded, and been stopped in due time. We know certainly, that if a sufficient time have not been allowed for the first period of the fermentation, the unfermented matter that remains being in too large a quantity, will then ferment in the bottles or close vessels in which the wine is put, and will occasion effects so much more sensible, as the first fermentation shall have been sooner interrupted: hence these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air disengaged during the fermentation.

We have an instance of these effects in the wine of Champagne, and in others of the same kind. The sensible fermentation of these wines is interrupted or rather surpressed, that they may have this sparkling quality. It is well known that these wines make the corks fly out of the bottles; that they sparkle and froth when they are poured into glasses; and lastly, that they have a taste much more lively and more piquant than wines that do not sparkle; but this sparkling quality, and all the effects depending on it, are only caused by a considerable quantity of carbonic acid gas, which is disengaged during the confined fermentation that the wine has undergone in close vessels. This air not having an opportunity of escaping, and of being dissipated as fast as it is disengaged, and being interposed betwixt all the parts of the wine, combines in some measure with them, and adheres in the same manner as it does to certain mineral waters, in which it produces nearly the same effects. When this air is entirely disengaged from these wines, they no longer sparkle, they lose their piquancy of taste, become mild, and even almost insipid.

Such are the qualities that wine acquires in time, when its first fermentation has not continued sufficiently long. These qualities are given purposely to certain kinds of wine to indulge taste or caprice; but such wines are supposed to be unfit for daily use. Wines for daily use ought to have undergone so completely the sensible fermentation, that the succeeding fermentation shall be insensible, or at least exceedingly little perceived. Wine, in which the first fermentation has been too far advanced, is liable to worse inconveniencies than that in which the first fermentation has been too quickly suppressed; for every fermentable liquor is from its nature in a continual intestine motion, more or less strong according to circumstances, from the first instant of the spirituous fermentation till it is completely purified: hence, from the time of the completion of the spirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very slow and insensible, when the wine is included in very close vessels, and in a cool place: but it gradually advances, so that in a certain time the wine, instead of being improved, becomes at last sour. This evil cannot be remedied; because the fermentation may advance, but cannot be reverted.

Wine-merchants, therefore, when their wines become sour, can only conceal or absorb this acidity by certain substances, as by alkalis and absorbent earths. But these substances give to wine a dark greenish colour, and a taste which, though not acid, is somewhat disagreeable. Besides, calcareous earths accelerate considerably the total destruction and putrefaction of the wine. Oxides of lead, having the property of forming with the acid of vinegar a salt of an agreeable saccharine taste, which does not alter the colour of the wine, and which besides has the advantage of stopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occasion most terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil consequences of lead, should, for the sake of gain, employ it for the purpose mentioned; but if there be any such persons, they must be considered as the poisoners and murderers of the public. At Alicant, where very sweet wines are made, it is the practice to mix a little lime with the grapes before they are pressed. This, however, can only neutralize the acid already existing in the grape.

If wine contain litharge, or any other oxide of lead, it may be discovered by evaporating some pints of it to dryness, and melting the residuum in a crucible, at the bottom of which a small button of lead may be found after the fusion: but an easier and more expeditious proof is by pouring into the wine some liquid sulphuret. If the precipitate occasioned by this addition of the sulphuret be white, or only coloured by the wine, we may know that no lead is contained in it; but if the precipitate be dark coloured, brown, or blackish, we may conclude, that it contains lead or iron.

The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is very little acid, and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste.

From what is here said concerning the acescency of wine, we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar-makers, as all honest wine-merchants do.

As the *must of* the grape contains a greater proportion of tartar than our currant and gooseberry juices do, I have been accustomed, for many years, to recommend in my lectures the addition of a small portion of that salt to our *must*, to make it ferment into a more genuine wine. Dr. M‘Culloch has lately prescribed the same addition in his popular treatise on the art of making wine.

The following is Mr. Brande's valuable table of the quantity of spirit in different kinds of wine:—

			Proportion of spirit per cent. by measure.
1.	Lissa,		26·47
	Ditto		24·35
		Average,	25·41
2.	Raisin wine,		26·40
	Ditto		25·77
	Ditto		23·20
		Average,	25·12
3.	Marsala,		26· 3
	Ditto		25· 5
		Average,	25· 9
4.	Madeira,		24·42
	Ditto		23·93
	Ditto (Sircial)		21·40
	Ditto		19·41
		Average,	22·27
5.	Currant wine,		20·55
6.	Sherry,		19·81
	Ditto		19·83
	Ditto		18·79
	Ditto		18·25
		Average,	19·17
7.	Teneriffe,		19·79
8.	Colares,		19·75
9.	Lachryma Christi		19·70
10.	Constantia, white,		19·75
11.	Ditto, red,		18·92
12.	Lisbon,		18·94
13.	Malaga (1666)		18·94
14.	Bucellas,		18·49
15.	Red Madeira,		22·30
	Ditto		18·40
		Average,	20·35
16.	Cape Muschat,		18·25
17.	Cape Madeira,		22·94
	Ditto		20·50
	Ditto		18·11
		Average,	20·51
18.	Grape wine,		18·11
19.	Calcavella,		19·20
	Ditto		18·10
		Average,	18·65
20.	Vidonia,		19·25
21.	Alba Flora,		17·26
22.	Malaga,		17·26
23.	White Hermitage,		17·43
24.	Rousillon,		19·00
	Ditto		17·26
		Average,	18.13
25.	Claret,		17·11
	Ditto		16·32
	Ditto		14·08
	Ditto		12·91
		Average,	15·10
26.	Malmsey Madeira,		16·40
27.	Lunel,		15·52
28.	Sheraaz,		15·52
29.	Syracuse,		15·28
30.	Sauterne,		14·22
31.	Burgundy,		16·60
	Ditto		15·22
	Ditto		14·53
	Ditto		11·95
		Average,	14·57
32.	Hock,		14·37
	Ditto		13·00
	Ditto (old in cask)		8·88
		Average,	12·08
33.	Nice,		14·63
34.	Barsac,		13·86
35.	Tent,		13·30
36.	Champagne, (still)		13·80

	Proportion of spirit per cent. by measure.
Champagne, (sparkling)	12·80
Ditto (red)	12·56
Ditto (ditto)	11·30
Average,	12·61
37. Red Hermitage,	12·32
38. Vin de Grave,	13·94
Ditto	12·80
Average,	13·37
39. Frontignac,	12·79
40. Cote Rotie,	12·32
41. Gooseberry wine,	11·84
42. Orange wine,—average of six samples made by a London manufacturer,	11·26
43. Tokay,	9·88
44. Elder wine,	9·87
45. Cider, highest average,	9·87
Ditto, lowest ditto	5·21
46. Perry, average of four samples,	7·26
47. Mead,	7·32
48. Ale (Burton)	8·88
Ditto (Edinburgh)	6·20
Ditto (Dorchester)	5·56
Average,	6·87
49. Brown stout,	6·80
50. London Porter, (average)	4·20
51. Ditto small beer, (ditto)	1·28
52. Brandy,	53·39
53. Rum,	53·68
54. Gin,	51·60
55. Scotch Whisky,	54·32
56. Irish ditto	53·90

WINE (OIL) OF. See Oil of Wine.

WITHERITE. Carbonate of barytes. See Heavy Spar.

WOAD, Isatis, Glastum, is a plant which grows wild in some parts of France, and on the coast of the Baltic Sea; the wild woad, and that which is cultivated for the use of the dyers, appear to be the same species of plant.

The preparation of woad for dyeing, as practised in France, is minutely described by Astruc, in his Memoirs for a Natural History of Languedoc.—The plant puts forth at first five or six upright leaves about a foot long and six inches broad: when these hang downwards, and turn yellow, they are fit for gathering; five crops are gathered in one year. The leaves are carried directly to a mill, much resembling the oil or tan-mills, and ground into a smooth paste. If this process were deferred for some time, they would putrefy, and send forth an insupportable stench. The paste is laid in heaps pressed close and smooth, and the blackish crust, which forms on the outside, reunited if it happen to crack: if this were neglected, little worms would be produced in the cracks, and the woad would lose part of its strength. After lying for fifteen days, the heaps are opened, the crust rubbed and mixed with the inside, and the matter formed into oval balls, which are pressed close and solid in wooden moulds. These are dried upon hurdles: in the sun they turn black on the outside, in a close place yellowish, especially if the weather be rainy. The dealers in this commodity prefer the first, though it is said the workmen find no considerable difference between the two. The good balls are distinguished by their being weighty, of a pretty agreeable smell, and, when rubbed, of a violet colour within.

For the use of the dyer these balls require a farther preparation: they are beaten with wooden mallets, on a brick or stone floor, into a gross powder, which is heaped up in the middle of the room to the height of four feet, a space being left for passing round the sides. The powder moistened with water ferments, grows hot, and throws out a thick fetid fume. It is shovelled backward and forward, and moistened every day for twelve days; after which it is stirred less frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures of different shades to water, to alcohol, to ammonia, and to fixed alkaline lixivia; rubbed on paper, it communicates a green stain. On diluting the powder with boiling water, and, after standing for some hours in a close vessel, adding about one-twentieth its weight of lime newly slacked, digesting in a gentle warmth, and stirring the whole together every three or four hours, a new fermentation begins; a blue froth rises to the surface, and the liquor, though it appears itself of a reddish colour, dyes woollen of a green; which, like the green from indigo, changes in the air to a blue. This is one of the nicest processes in the art of dyeing, and does not well succeed in the way of a small experiment.

WOLLASTONITE. A mineral found in small masses, of a brownish tinge externally; transparent and colourless internally, or of a flesh colour; highly crystalline. It seems to be a tabular spar, from the measurements by the reflective goniometer of its mechanical divisions. A more distinctive mineral honour should be appropriated to Dr. Wollaston.

WOOD (OPAL). See Opal.

WOOD (ROCK). The ligniform asbestus.

WOOD-STONE. A sub-species of hornstone.

WOOD-TIN. See Ores of Tin.

WOOL. See Appendix.

WOOTZ. The metal extracted from some kind of iron ore in the East Indies, apparently of good quality. It contains more carbon than steel, and less than cast-iron, but from want of skill in the management is far from homogeneous.—*Phil. Trans.*

WORT. See Beer, Distillation, and Fermentation.

WOLFRAM. See Ores of Tungsten.

Y

YANOLITE. Axinite.

YEAST. See FERMENTATION, and BREAD.

YELLOW EARTH. Colour ochre-yellow. Massive. Dull. Fracture slaty or earthy. Streak somewhat shining. Opaque. Soils slightly. Soft. Easily frangible. Adheres to the tongue. Feels rather greasy. Sp. gr. 2·24. Before the blowpipe it is converted into a black and shining enamel. Its constituents are, silica 92, alumina 2, lime 3, iron 3. — *Merat-Guillot.* It is found at Wehraw in Upper Lusatia, where it is associated with clay and clay-ironstone. When burnt, it is sold by the Dutch as a pigment under the name of English red. It was used as a yellow paint by the ancients.

YENITE. Lievrite.

YTTRIA. This is a new earth discovered in 1794 by Professor Gadolin, in a stone from Ytterby in Sweden. See GADOLINITE.

It may be obtained most readily by fusing the gadolinite with two parts of caustic potash, washing the mass with boiling water, and filtering the liquor, which is of a fine green. This liquor is to be evaporated, till no more oxide of manganese falls down from it in a black powder; after which the liquid is to be saturated with nitric acid. At the same time digest the sediment, that was not dissolved, in very dilute nitric acid, which will dissolve the earth with much heat, leaving the silex, and the highly oxided iron, undissolved. Mix the two liquors, evaporate them to dryness, redissolve, and filter, which will separate any silex or oxide of iron that may have been left. A few drops of a solution of carbonate of potash will separate any lime that may be present, and a cautious addition of hydrosulphuret of potash will throw down the oxide of manganese that may have been left; but if too much be employed, it will throw down the yttria likewise. Lastly, the yttria is to be precipitated by pure ammonia, well washed, and dried.

Yttria is perfectly white, when not contaminated with oxide of manganese, from which it is not easily freed. Its specific gravity is 4·842. It has neither taste nor smell. It is infusible alone; but with borax melts into a transparent glass, or opaque white if the borax were in excess. It is insoluble in water, and in caustic fixed alkalis; but it dissolves in carbonate of ammonia, though it requires five or six times as much as glucine. It is soluble in most of the acids. The oxalic acid, or oxalate of ammonia, forms precipitates in its solutions perfectly resembling the muriate of silver. Prussiate of potash, crystallized and redissolved in water, throws it down in white grains; phosphate of soda, in white gelatinous flakes; infusion of galls, in brown flocks.

Some chemists are inclined to consider yttria rather as a metallic than as an earthy substance: their reasons are, its specific gravity, its forming coloured salts, and its property of oxygenizing muriatic acid after it has undergone a long calcination. *Crell's Chem. An.—Scherer's Journ.—Annales de Chimie.*

When yttria is treated with potassium in the same manner as the other earths, similar results are obtained; the potassium becomes potash, and the earth gains appearances of metallization; so that it is scarcely to be doubted, says Sir H. Davy, that yttria consists of inflammable matter, metallic in its nature, combined with oxygen. According to Klaproth, 55 parts of yttria combine with 18 parts of carbonic acid; consequently, if it be supposed that the carbonate of yttria consists of one prime proportion of earth and one of acid, its prime equivalent will be 8·403; and that of its metallic basis probably 7·4. The salts of yttria have the following general characters:—

1. Many of them are insoluble in water.
2. Precipitates are occasioned in those which dissolve, by phosphate of soda, carbonate of soda, oxalate of ammonia, tartrate of potash, and ferroprussiate of potash.
3. If we except the sweet-tasted soluble sulphate of yttria, the other salts of this earth resemble those with base of lime in their solubility. See SALTS.

YTTRO-TANTALITE. An ore of TANTALUM.

YTTRO-CERITE. Colours reddish and grayish-white, and violet-blue. Massive, and in crusts. Cleavage indistinct. Opaque. Yields to the knife. Scratches fluor. Sp. gr. 3·447. Its constituents are, oxide of cerium 13·15, yttria 14·6, lime 47·77, fluoric acid 24·45.—*Berzelius.* It has hitherto been found only at Finbo, near Fahlun in Sweden, imbedded in quartz or incrusting pyrophysalite.

Z

ZAFFRE, or SAFFRE, is the residuum of cobalt, after the sulphur, arsenic, and other volatile matters of this mineral have been expelled by calcination.

The zaffre that is commonly sold, and which comes from Saxony, is a mixture of oxide of cobalt with some vitrifiable earth. It is of a gray colour, as all the oxides of cobalt are before vitrification.

ZEAGONITE. Abrazite.

ZEINE. The zeine of John Gorham is obtained from maize of Indian corn, by infusing it in water, filtering and treating with alcohol the matter insoluble in the former liquid, and evaporating the alcoholic solution. We thus obtain a yellow substance having the appearance of wax; it is soft, ductile, tough, elastic, insipid, nearly void of smell, and denser than water. It affords no ammonia on decomposition by heat; though it approaches in its nature to gluten.

ZEOLITE. The name of a very extensive mineral *genus*, containing the following species:—1. Dodecahedral zeolite or leucite; 2. hexahedral zeolite or analcime; 3. rhomboidal zeolite, chabasite, or chabasie; 4. pyramidal zeolite, or cross-stone; 5. diprismatic zeolite, or laumonite; 6. prismatic zeolite, or mesotype, divided into three sub-species,—fibrous zeolite, natrolite, and mealy zeolite; 7. prismatoidal zeolite, or stilbite, comprehending foliated zeolite, and radiated zeolite; 8. axifrangible zeolite, or apophyllite. The following belong to this place:

6. *Prismatic zeolite* or *mesotype*.

§ 1. *Fibrous zeolite*, of which there are two kinds; the acicular or needle zeolite, and common fibrous zeolite.

a. Acicular or *needle zeolite*, the mesotype of Haüy. Colours grayish, yellowish, or reddish-white. Massive, in distinct concretions, and crystallized. Primitive form, a prism of 91° 25′. The following are secondary figures:—An acicular rectangular four-sided prism, very flatly acuminated with four planes, set on the lateral planes: sometimes two of the acuminating planes disappear, when there is formed an acute bevelment, or the prism is sometimes truncated on the edges. Lateral planes longitudinally streaked. Shining, inclining to pearly. Cleavage twofold. Fracture small grained uneven. Fragments splintery. Translucent. Refracts double. As hard as apatite. Brittle. Sp. gr. 2.0 to 2.3. It intumesces before the blowpipe, and forms a jelly with acids. It becomes elastic by heating, and retains this property some time after it has cooled. The free extremity of the crystal with the acumination, shows positive, the attached end, negative electricity. Its constituents are, silica 50.24, alumina 29.3, lime 9.46, water 10.—*Vauquelin.* It occurs in secondary trap-rocks, as in basalt, greenstone, and amygdaloid. It is found near the village of Old Kilpatrick, Dumbartonshire; in Ayrshire and Perthshire, always in trap rocks; in Iceland and in the Faroe Islands.

b. Common fibrous zeolite. Colour white. Massive, in distinct concretions, and in capillary crystals. Glimmering, pearly. Fragments splintery. Faintly translucent. Hardness as before. Rather brittle. Sp. gr. 2.16 to 2.2. Chemical characters and situations as above. Its constituents are, silica 49, alumina 27, soda 17, water 9.5.—*Smithson.*

§ 2. *Mealy zeolite.* Colour white, of various shades. Massive, imitative, in a crust, or in delicate fibrous concretions. Feebly glimmering. Fracture coarse earthy. Opaque. The mass is soft, but the minute parts as hard as the preceding. Sectile. Most easily frangible. Does not adhere to the tongue. Feels meagre. Sometimes so light as nearly to float on water. It intumesces, and gelatinizes as the preceding. Its constituents are, silica 60, alumina 15.6, lime 8, oxide of iron 1.8, loss by exposure to heat, 11.6.—*Hisinger.* It occurs like the others. It is found near Tantallon-castle, in East Lothian, and in the islands of Skye, Mull, and Canna.

7. *Prismatoidal zeolite*, or *stilbite.* Of this there are two sub-species; the foliated and radiated.

§ 1. *Foliated zeolite*, the stilbite of Haüy. Colour white, of various shades. Massive, disseminated, imitative, in distinct granular concretions, and crystallized. Primitive form, a prism of 99° 22′. Secondary forms are, a low oblique four-sided prism, variously truncated; a low equiangular six-sided prism; and an eight-sided prism, from truncation of all the edges of the four-sided prism. Lateral planes transversely streaked. Shining, pearly. Cleavage single. Fracture conchoidal. Translucent. Refracts single. As hard as calcareous spar. Brittle. Sp. gr. 2 to 2.2. It intumesces and phosphoresces before the blowpipe, but does not form a jelly with acids. Its constituents are, silica 52.6, alumina 17.5, lime 9, water 18.5.—*Vauquelin.* It occurs principally in secondary amygdaloid, either in drusy cavities or in contemporaneous veins. It is also met with in primitive and transition mountains. Very beautiful specimens of the red foliated and radiated zeolites are found at Carbeth in Stirlingshire, and at Loch Humphrey in Dumbartonshire; also in the secondary trap rocks of the Hebrides, as of Skye, Canna, and Mull; and in the north of Ireland.

§ 2. *Radiated zeolite.* Stilbite of Haüy. Colours yellowish-white and grayish-white. Massive, in angular pieces, in prismatic and granular concretions, and crystallized in a rectangular four-sided prism, variously modified by acuminations. Shining, pearly. Translucent. Hardness and chemical characters as above. Brittle. Sp. gr. 2.14. Its constituents are, silica 40.98, alumina 39.09, lime 10.95, water 16.5.—*Meyer.* Its situations are as the preceding.—*Jameson.*

ZERO. The commencement of a scale marked O. Thus we say the zero of Fahrenheit, which is 32° below the melting point of ice; the zero of the centigrade scale, which coincides with the freezing of water. The absolute zero, is the imaginary point in the scale of temperature, when the whole heat is exhausted; the term of absolute cold, or privation of caloric. See CALORIC.

ZIMOME. The gluten of wheat, treated by alcohol, is reduced to the third part of its bulk. This diminution is owing, not merely to the loss of gliadine, but likewise to that of water. The residue is zimome, which may be obtained pure by boiling it repeatedly in alcohol, or by digesting it in repeated portions of that liquid cold, till it no longer gives out any gliadine. See GLIADINE.

Zimome thus purified has the form of small globules, or constitutes a shapeless mass, which is hard, tough, destitute of cohesion, and of an ash-white colour. When washed in water, it recovers part of its viscosity, and becomes quickly brown, when left in contact of the air. It is specifically heavier than water. Its mode of fermenting is no longer that of gluten; for when it putrefies it exhales a fetid urinous odour. It dissolves completely in vinegar, and in the mineral acids at a boiling temperature. With caustic potash, it combines and forms a kind of soap. When put into lime water, or into the solutions of the alkaline carbonates, it becomes harder and assumes a new appearance without dissolving. When thrown upon red-hot coals, it exhales an odour similar to that of burning hair or hoofs, and burns with flame.

Zimome is to be found in several parts of vegetables. It produces various kinds of fermentation, according to the nature of the substance with which it comes in contact.

ZINC is a metal of a bluish-white colour, somewhat brighter than lead; of considerable hardness, and so malleable as not to be broken with the hammer, though it cannot be much extended in this way. It is very easily extended by the rollers of the flatting mill. Its sp. gr. is from 6.9 to 7.2. In a temperature between 210° and 300° of F., it has so much ductility that it can be drawn into wire, as well as laminated, for which a patent has been obtained by Messrs. Hobson and Sylvester of Sheffield. The zinc thus annealed and wrought retains the malleability it had acquired.

When broken by bending, its texture appears as if composed of cubical grains. On account of its imperfect malleability, it is difficult to reduce it into small parts by filing or hammering; but it may be granulated, like the malleable metals, by pouring it, when fused, into cold water; or, if it be heated nearly to melting, it is then sufficiently brittle to be pulverized.

It melts long before ignition, at about the 700th degree of Fahrenheit's thermometer; and, soon after it becomes red-hot, it burns with a dazzling white flame, of a bluish or yellowish tinge, and is oxidized with such rapidity, that it flies up in the form of white flowers, called the *flowers of zinc*, or *philosophical wool.* These are generated so plentifully, that the access of air is soon intercepted; and the combustion ceases, unless the matter be stirred, and a considerable heat kept up. The white oxide of zinc is not volatile, but is driven up merely by the force of the combustion. When it is again urged by a strong heat, it becomes converted into a clear yellow glass. If zinc be heated in closed vessels, it rises without decomposition.

The oxide of zinc, according to the experiments of MM. Gay Lussac and Berzelius, consists of 100 metal + 2.44 oxygen; whence the prime equivalent appears to be 4.1. Sir H. Davy makes it 4.4 from his own and his brother's experiments.

When zinc is burned in chlorine, a solid substance is formed of a whitish-gray colour, and semitransparent. This is the only chloride of zinc, as there is only one oxide of the metal. It may likewise be made by heating together zinc filings and corrosive sublimate. It is as soft as wax, fuses at a temperature a little above 212°, and rises in the gaseous form at a heat much below ignition. Its taste is intensely acrid, and it corrodes the skin. It acts upon water, and dissolves in it, producing much heat; and its solution, decomposed by an alkali, affords the white hydrated oxide of zinc. This chloride has been called *butter of zinc*, and *muriate of zinc.* From the experiments of Dr. John Davy, it consists of nearly equal weights of zinc and chlorine. The equivalent proportions appear to be,—

Zinc 4.25 + chlorine 4.5.

Blende is the native sulphuret of zinc. The two bodies are difficult to combine artifically. The salts of zinc possess the following general characters:—

1. They generally yield colourless solutions with water.

2. Ferroprussiate of potash, hydrosulphuret of potash, hydriodate of potash, sulphuretted hydrogen, and alkalis, occasion white precipitates.

3. Infusion of galls produces no precipitate.

The diluted sulphuric acid dissolves zinc: at the same time that the temperature of the solvent is increased, and much hydrogen escapes, an undissolved residue is left, which has been supposed to consist of plumbago. Proust, however, says, that it is a mixture of arsenic, lead, and copper. As the combination of the sulphuric acid and the oxide proceeds, the temperature diminishes, and the sulphate of zinc, which is more soluble in hot than cold water, begins to separate, and disturb the transparency of the fluid. If more water be added, the salt may be obtained in fine prismatic four-sided crystals. The white vitriol, or copperas, usually sold, is crystallized hastily, in the same manner as loaf-sugar, which on this account it resembles in appearance; it is slightly efflorescent. The white oxide of zinc is soluble in the sulphuric acid, and forms the same salt as is afforded by zinc itself.

The hydrogen gas that is extricated from water by the action of sulphuric acid carries up with it a portion of zinc, which is apparently dissolved in it; but this is deposited spontaneously, at least in part, if not wholly, by standing. It burns with a brighter flame than common hydrogen.

Sulphate of zinc is prepared in the large way from some varieties of the native sulphuret. The ore is roasted, wetted with water, and exposed to the air. The sulphur attracts oxygen, and is converted into sulphuric acid; and the metal, being at the same time oxidized, combines with the acid. After some time the sulphate is extracted by solution in water; and the solution being evaporated to dryness, the mass is run into moulds. Thus the white vitriol of the shops generally contains a small portion of iron, and sometimes of lead.

Sulphurous acid dissolves zinc, and sulphuretted hydrogen is evolved. The solution, by exposure to the air, deposits needly crystals, which, according to Fourcroy and Vauquelin, are sulphuretted sulphite of zinc. By dissolving oxide of zinc in sulphurous acid, the pure sulphite is obtained. This is soluble, and crystallizable.

Diluted nitric acid combines rapidly with zinc, and produces much heat, at the same time that a large quantity of nitrous air flies off. The solution is very caustic, and affords crystals by evaporation and cooling, which slightly detonate upon hot coals, and leave oxide of zinc behind. This salt is deliquescent.

Muriatic acid acts very strongly upon zinc, and disengages much hydrogen; the solution, when evaporated, does not afford crystals, but becomes gelatinous. By a strong heat it is partly decomposed, a portion of the acid being expelled, and part of the muriate sublimes and condenses in a congeries of prisms.

Phosphoric acid dissolves zinc. The phosphate does not crystallize, but becomes gelatinous, and may be fused by a strong heat. The concrete phosphoric acid heated with zinc filings is decomposed.

Fluoric acid likewise dissolves zinc.

The boracic acid digested with zinc becomes milky; and if a solution of borax be added to a solution of muriate or nitrate of zinc, an insoluble borate of zinc is thrown down.

A solution of carbonic acid in water dissolves a small quantity of zinc, and more readily its oxide. If the solution be exposed to the air, a thin iridescent pellicle forms on its surface.

The acetic acid readily dissolves zinc, and yields by evaporation crystals of acetate of zinc, forming rhomboidal or hexagonal plates. These are not altered by exposure to the air, are soluble in water, and burn with a blue flame.

The succinic acid dissolves zinc with effervescence, and the solution yields long, slender, foliated crystals.

Zinc is readily dissolved in benzoic acid, and the solution yields needle-shaped crystals, which are soluble both in water and in alcohol. Heat decomposes them by volatilizing their acid.

The oxalic acid attacks zinc with a violent effervescence, and a white powder soon subsides, which is oxalate of zinc. If oxalic acid be dropped into a solution of sulphate, nitrate, or muriate of zinc, the same salt is precipitated; it being scarcely soluble in water, unless an excess of acid be present. It contains seventy-five per cent. of metal.

The tartaric acid likewise dissolves zinc with effervescence, and forms a salt difficult of solution in water.

The citric acid attacks zinc with effervescence, and small brilliant crystals of citrate of zinc are gradually deposited, which are insoluble in water. Their taste is styptic and metallic, and they are composed of equal parts of the acid and of oxide of zinc.

The malic acid dissolves zinc, and affords beautiful crystals by evaporation.

Lactic acid acts upon zinc with effervescence, and produces a crystallizable salt.

The metallic acids likewise combine with zinc. If arsenic acid be poured on it, an effervescence takes place, arsenical hydrogen gas is emitted, and a black powder falls down, which is arsenic in the metallic state, the zinc having deprived a portion of the arsenic, as well as the water, of its oxygen. If one part of zinc filings and two parts of dry arsenic acid be distilled in a retort, a violent detonation takes place when the retort becomes red, occasioned by the sudden absorption of the oxygen of the acid by the zinc. The arseniate of zinc may be precipitated by pouring arsenic acid into the solution of acetate of zinc, or by mixing a solution of an alkaline arseniate with that of sulphate of zinc. It is a white powder, insoluble in water.

By a similar process zinc may be combined with the molybdic acid, and with the oxide of tungsten, the tungstic acid of some, with both of which it forms a white insoluble compound; and with the chromic acid, the result of which compound is equally insoluble, but of an orange-red colour.

Zinc likewise forms some triple salts. Thus, if the white oxide of zinc be boiled in a solution of muriate of ammonia, a considerable portion is dissolved; and though part of the oxide is again deposited as the solution cools, some of it remains combined with the acid and alkali in the solution, and is not precipitable either by pure alkalis or their carbonates. This triple salt does not crystallize.

If the acidulous tartrate of potash be boiled in water with zinc filings, a triple compound will be formed, which is very soluble in water, but not easily crystallised. This, like the preceding, cannot be precipitated from its solution either by pure or carbonated alkalis.

A triple sulphate of zinc and iron may be formed by mixing together the sulphates of iron and of zinc dissolved in water, or by dissolving iron and zinc in dilute sulphuric acid. This salt crystallizes in rhomboids, which nearly resemble the sulphate of zinc in figure, but are of a pale green colour. In taste, and in degree of solubility, it differs little from the sulphate of zinc. It contains a much larger proportion of zinc than of iron.

A triple sulphate of zinc and cobalt, as first noticed by Link, may be obtained by digesting zaffre in a solution of sulphate of zinc. On evaporation, large quadrilateral prisms are obtained, which effloresce on exposure to the air.

Zinc is precipitated from acids by the soluble earths and the alkalis: the latter redissolve the precipitate, if they be added in excess.

Zinc decomposes, or alters, the neutral sulphates in the dry way. When fused with sulphate of potash, it converts that salt into a sulphuret: the zinc at the same time being oxidized, and partly dissolved in the sulphuret. When pulverized zinc is added to fused nitre, or projected together with that salt into a red-hot crucible, a very violent detonation takes place; insomuch that it is necessary for the operator to be careful in using only small quantities, lest the burning matter should be thrown about. The zinc is oxidized, and part of the oxide combines with the alkali, with which it forms a compound soluble in water.

Zinc decomposes common salt, and also sal ammoniac, by combining with the muriatic acid. The filings of zinc likewise decompose alum, when boiled in a solution of that salt, probably by combining with its excess of acid.

Zinc may be combined with phosphorus, by projecting small pieces of phosphorus on the zinc melted in a crucible, the zinc being covered with a little resin, to prevent its oxidation. Phosphuret of zinc is white, with a shade of bluish-gray, has a metallic lustre, and is a little malleable. When zinc and phosphorus are exposed to heat in a retort, a red sublimate rises, and likewise a bluish sublimate, in needly crystals, with a metallic lustre. If zinc and phosphoric acid be heated together, with or without a little charcoal, needly crystals are sublimed, of a silvery-white colour. All these, according to Pelletier, are phosphuretted oxides of zinc.

Most of the metallic combinations of zinc have been already treated of. It forms a brittle compound with antimony; and its effects on manganese, tungsten, and molybdena, have not yet been ascertained.

An alloy of zinc and iron has been collected by Mr. Herapath in a zinc manufactory at Bristol. It lined the tube leading from the retort. It was hard and brittle, the fracture showing broad facets like zinc, but of a duller gray colour, with surfaces more rough and granular. Its sp. grav. was 7·172. It consisted of 92·6 zinc + 7·4 iron in 100.—*Phil. Magazine*, lxii. 168.

ZIRCONIA was first discovered in the jargon of Ceylon by Klaproth, in 1789, and it has since been found in the jacinth. To obtain it, the stone should be calcined and thrown into cold water, to render it friable, and then powdered in an agate mortar. Mix the powder with nine parts of pure potash, and project the mixture by spoonfuls into a red-hot crucible, taking care that each portion is fused before another is added. Keep the whole in fusion, with an increased heat, for an hour and half. When cold, break the crucible, separate its contents, powder and boil in water, to dissolve the alkali. Wash the insoluble part; dissolve in muriatic acid; heat the solution, that the silex may fall down; and precipitate the zircon by caustic fixed alkali. Or the zircon may be precipitated by carbonate of soda, and the carbonic acid expelled by heat.

New Process for preparing pure Zirconia. Powder the zircons very fine, mix them with two parts of pure potash, and heat them red-hot in a silver crucible, for an hour. Treat the substance obtained with distilled water, pour it on a filter, and wash the insoluble part well; it will be a compound of zirconia, silex, potash, and oxide of iron. Dissolve it in muriatic acid, and evaporate to dryness, to separate the silex. Redissolve the muriates of zirconia and iron in water; and to separate the zirconia which adheres to the silex, wash it with weak muriatic acid, and add this to the solution. Filter the fluid, and precipitate the zirconia and iron by pure ammonia; wash the precipitates well, and then treat the hydrates with oxalic acid, boiling them well together, that the acid may act on the iron, retaining it in solution, whilst an insoluble oxalate of zirconia is formed. It is then to be filtered, and the oxalate washed, until no iron can be detected in the water that passes. The earthy oxalate is, when dry, of an opaline colour. After being well washed, it is to be decomposed by heat in a platinum crucible.

Thus obtained, the zirconia is perfectly pure, but is not affected by acids. It must be re-acted on by potash as before, and then washed until the alkali is removed. Afterwards dissolve it in muriatic acid, and precipitate by ammonia. The hydrate thrown down, when well washed, is perfectly pure, and easily soluble in acids.—*MM. Dubois and Silveira, Ann. de Chimie et de Phys.* xiv. p. 110.

Zircon is a fine white powder, without taste or smell, but somewhat harsh to the touch. It is insoluble in water; yet if slowly dried, it coalesces into a semitransparent yellowish mass, like gum-arabic, which retains one-third its weight of water. It unites with all the acids. It is insoluble in pure alkalis; but the alkaline carbonates dissolve it. Heated with the blowpipe it does not melt, but emits a yellowish phosphoric light. Heated in a crucible of charcoal, bedded in charcoal powder, placed in a stone crucible, and exposed to a good forge fire for some hours, it undergoes a pasty fusion, which unites its particles into a grey opaque mass, not truly vitreous, but more resembling porcelain. In this state it is sufficiently hard to strike fire with steel, and scratch glass; and is of the specific gravity of 4·3.

There is the same evidence for believing that zirconia is a compound of a metal and oxygen, as that afforded by the action of potassium on the other earths. The alkaline metal, when brought into contact with zirconia ignited to whiteness, is, for the most part, converted into potash; and dark particles, which, when examined by a magnifying glass, appear metallic in some parts, of a chocolate-brown in others, are found diffused through the potash and the decompounded earth.

According to Sir H. Davy, 4·66 is the prime equivalent of zirconium on the oxygen scale, and 5·66 that of zirconia.

Zirconium has been recently obtained by M. Berzelius by a method exactly similar to that for silicium. See SILICIUM. Zirconium is as black as carbon, does not oxidise in water or in muriatic acid, but nitro-muriatic and fluoric acids dissolve it; the last with the disengagement of hydrogen. At a temperature but slightly elevated it burns with great intensity. It combines with sulphur. Its sulphuret is of a chesnut-brown colour like silicium, and insoluble in muriatic acid or the alkalis. It burns with brilliancy, producing sulphurous acid gas and zirconia. *Ann. de Chimie et de Phys.* xxvi. 41.

ZOISITE. A sub-species of prismatoidal augite, which is divided into two kinds, the common and friable.

§ 1. *Common zoisite.* Colour yellowish-gray. Massive, in granular and prismatic concretions, and crystallised in very oblique four-sided prisms, in which the obtuse lateral edges are often rounded, so that the crystals have a reed-like form. Shining, or glistening and resino-pearly. Cleavage double. Fracture small grained uneven. Feebly translucent. As hard as epidote. Very easily frangible. Sp. gr. 3.3. It is affected by the blowpipe, as epidote. Its constituents are, silica 43, alumina 29, lime 21, oxide of iron 3.—*Klaproth.* At the Saualp in Carinthia, it is found imbedded in a bed of quartz, along with cyanite, garnet, and augite; or it takes the place of felspar in a granular rock, composed of quartz and mica. It is found in Glen-Elg in Inverness-shire, and in Shetland.

§ 2. *Friable zoisite.* Colour reddish-white, which is spotted with pale peach-blossom red. Massive, and in very fine loosely aggregated granular concretions. Feebly glimmering. Fracture intermediate between earthy and splintery. Translucent on the edges. Semi-hard. Brittle. Sp. gr. 3.3. Its constituents are, silica 44, alumina 32, lime 20, oxide of iron 2.5.—*Klaproth.* It occurs imbedded in green talc, at Radelgraben in Carinthia.

ZOOPHYTES. Scarcely any chemical experiments have been published on these interesting subjects, if we except the admirable dissertation by Mr. Hatchett, in the Philosophical Transactions for 1800. From this dissertation, and from a few experiments of Merat-Guillot, we learn that the hard zoöphytes are composed chiefly of three ingredients:—1. An animal substance of the nature of coagulated albumen, varying in consistency; sometimes being gelatinous and almost liquid, at others of the consistency of cartilage. 2. Carbonate of lime. 3. Phosphate of lime.

In some zoöphytes the animal matter is very scanty, and phosphate of lime wanting altogether; in others, the animal matter is abundant, and the earthy salt pure carbonate of lime; while in others the animal matter is abundant, and the hardening salt a mixture of carbonate of lime and phosphate of lime; and there is a fourth class almost destitute of earthy salts altogether. Thus, there are four classes of zoöphytes: the first resemble porcellaneous shells; the second resemble mother-of-pearl shells; the third resemble crusts; and the fourth horn.

1. When the *madrepora virginea* is immersed in diluted nitric acid, it effervesces strongly, and is soon dissolved. A few gelatinous particles float in the solution, which is otherwise transparent and colourless. Ammonia precipitates nothing; but its carbonate throws down abundance of carbonate of lime. It is composed, then, of carbonate of lime and a little animal matter. The following zoöphytes yield nearly the same results:—

Madrepora muricata,
———— labyrinthica,

Millepora cerulea,
——— alcicornis,
Tubipora musica.

2. When the *madrepora ramea* is plunged into weak nitric acid, an effervescence is equally produced; but after all the soluble part is taken up, there remains a membrane which retains completely the original shape of the madrepore. The substance taken up is pure lime. Hence, this madrepore is composed of carbonate of lime, and a membranaceous substance, which, as in mother-of-pearl shells, retains the figure of the madrepore. The following zoöphytes yield nearly the same results:—

Madrepora fascicularis,
Millepora cellulosa,
——— fascialis,
——— truncata,
Iris hippuris.

The following substances, analysed by Merat-Guillot, belong to this class from their composition, though it is difficult to say what are the species of zoöphytes which were analyzed. By *red coral*, he probably meant the *gorgonia nobilis*, though that substance is known, from Hatchett's analysis, to contain also some phosphate:—

	White coral.	Red coral.	Articulated coralline.
Carbonate of lime,	50	53·5	49
Animal matter,	50	46·5	51
	100	100·0	100*

3. When the *madrepora polymorpha* is steeped in weak nitric acid, its shape continues unchanged; there remaining a tough membranaceous substance of a white colour, and opaque, filled with a transparent jelly. The acid solution yields a slight precipitate of phosphate of lime, when treated with ammonia, and carbonate of ammonia throws down a copious precipitate of carbonate of lime. It is composed, therefore, of animal substance, partly in the state of jelly, partly in that of membrane, and hardened by carbonate of lime, together with a little phosphate of lime.

Flustra foliacea, treated in the same manner, left a finely reticulated membrane, which possessed the properties of coagulated albumen. The solution contained a little phosphate of lime, and yielded abundance of carbonate of lime when treated with the alkaline carbonates. The *corallina opuntia*, treated in the same manner, yielded the same constituents; with this difference, that no phosphate of lime could be detected in the fresh coralline, but the solution of burnt coralline yielded traces of it. The *iris ochracea* exhibits the same phenomena, and is formed of the same constituents. When dissolved in weak nitric acid, its colouring matter falls in the state of a fine red powder, neither soluble in nitric nor muriatic acid, nor changed by them; whereas the tingeing matter of the *tubipora musica* is destroyed by these acids. The branches of this iris are divided by a series of knots. These knots are cartilaginous bodies connected together by a membraneous coat. Within this coat there is a conical cavity filled with the earthy or coralline matter; so that, in the recent state, the branches of the iris are capable of considerable motion, the knots answering the purpose of joints. See CORAL.

Mr. Hatchett analyzed many species of sponges, but found them all similar in their composition. The *spongia cancellata*, *oculata*, *infundibuliformis*, *palmata*, and *officinalis*, may be mentioned as specimens. They consist of gelatin, which they gradually give out to water, and a thin brittle membranous substance, which possesses the properties of coagulated albumen.

ZUMATES. Combinations of the zumic acid with the salifiable bases.

ZUMIC ACID. See ACID (ZUMIC).

ZUNDERERZ. Tinder ore. An ore of silver.

ZURLITE. A mineral occurring in rectangular prisms and in botroidal masses, of an asparagus green colour. It yields to the knife, but emits sparks with steel. Sp. gr. 3·274. Melts with borax into a black glass. It is found on mount Vesuvius with calcareous spar.

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* Merat-Guillot, *Ann. de Chim.* xxxiv. 71.

APPENDIX.

TABLE I.—Dr. Wollaston's Original Numerical Table of Chemical Equivalents.

Dr Wollaston's numbers represent the weights of the atoms of bodies, oxygen being called ten.

1.	Hydrogen	1·32
2.	Oxygen	10·00
3.	Water	11·32
4.	Carbon	7·54
5.	Carbonic acid (20 oxygen)	27·54
6.	Sulphur	20·00
7.	Sulphuric acid (30 oxygen)	50·00
8.	Phosphorus	17·40
9.	Phosphoric acid (20 oxygen)	37·40
10.	Azote or nitrogen	17·54
11.	Nitric acid (50 oxygen)	67·54
12.	Muriatic acid, dry	34·10
13.	Oxymuriatic acid (10 oxygen)	44·10
14.	Chlorine 44·10 + 1·32 hydrogen = muriatic acid gas	45·42
15	Oxalic acid	47·0
16.	Ammonia	21·5
17.	Soda	39·1
18.	Sodium (above — 10 oxygen)	29·1
19.	Potash	59·1
20.	Potassium (above — 10 oxygen)	49·1
21.	Magnesia	24·6
22.	Lime	35·46
23.	Calcium (above — 10 oxygen)	25·46
24.	Strontites	69·00
25	Barytes	97·00
26.	Iron	34·50
	Black oxide (10 oxygen)	44·50
	Red oxide (15 oxygen)	49·50
27.	Copper	40·00
	Black oxide (10 oxygen)	50·00
28.	Zinc	41·00
	Oxide (10 oxygen)	51·00
29.	Mercury	125·50
	Red oxide (10 oxygen)	135·50
	Black oxide (125·5 mercury)	261·00
30.	Lead	129·50
	Litharge (10 oxygen)	139·50
31.	Silver	135·00
	Oxide (10 oxygen)	145·00
32.	Sub-carbonate of ammonia	40·00
	Bi-carbonate (27·5 carbonic acid)	76·50
33.	Sub-carbonate of soda	66·60
	Bi-carbonate (27·5 C. A. + 11·3 water)	105·50
34.	Subcarbonate of potash	86·00
	Bi-carbonate (27·5 C. A. + 11·3 water)	125·50
35.	Carbonate of lime	63·00
36.	——— barytes	124·50
37.	——— lead	167·00
38.	Sulphuric acid, dry	50·00
39.	Do. sp. gr. 1·850 (50 + 11·3 water)	61·30
40.	Sulphate of soda (10 water = 113·2)	202·30
41.	Sulphate of potash	109·10
42.	Sulphate of magnesia, dry	74·60
	Do. crystallized (7 water = 79·3)	153·90
43.	Sulphate of lime, dry	85·50
	Crystallized (2 water = 22·64)	108·10
44.	Sulphate of strontites	119·00
45.	——— barytes	147·00
46.	——— copper (1 acid + 1 oxide + 5 water)	156·60
47.	——— iron (7 water)	173·80
48.	——— zinc (do.)	180·20
49.	——— lead	189·50
50.	Nitric acid, dry	67·54
	Nitric acid, sp. gr. 1·50 (2 water = 22·64)	90·20
51.	Nitrate of soda	106·60
52.	——— potash	126·60
53.	——— lime	103·00
54.	——— barytes	164·50
55.	——— lead	207·00
56.	Muriate of ammonia	66·90
57.	——— soda	73·20
58.	——— potash	93·20
	Oxymuriate of do. (60 oxygen)	153·20
59.	Muriate of lime	169·60
60.	——— barytes	131·00
61.	——— lead	173·60
62.	——— silver	179·10
63.	——— mercury	170·10
64.	Submuriate of do. (1 acid + 1 oxygen + 2 mercury)	296·10
65.	Phosphate of lead	176·90
66.	Oxalate of lead	186·50
67.	Bin-oxalate of potash	153·00

TABLES, exhibiting a collective View of all the Frigorific Mixtures contained in Mr. Walker's Publication, 1808.

II.—*Table, consisting of Frigorific Mixtures, having the power of generating or creating Cold, without the aid of Ice, sufficient for all useful and philosophical purposes, in any part of the World at any Season.*

Frigorific Mixtures without Ice.

MIXTURES.		Thermometer sinks.	Deg. of cold produced.
Muriate of ammonia . Nitrate of potash . . Water . . .	5 parts 5 16	From + 50° to + 10°	40°
Muriate of ammonia . Nitrate of potash . . Sulphate of soda . . Water . . .	5 parts 5 8 16	From + 50° to + 4°	46
Nitrate of ammonia . Water . . .	1 part 1	From + 50° to + 4°	46
Nitrate of ammonia . . Carbonate of soda . . Water . . .	1 part 1 1	From + 50° to — 7°	57
Sulphate of soda . . Diluted nitric acid . .	3 parts 2	From + 50° to — 3°	53
Sulphate of soda . . Muriate of ammonia . Nitrate of potash . . Diluted nitric acid . .	6 parts 4 2 4	From + 50° to — 10°	60
Sulphate of soda . . Nitrate of ammonia . Diluted nitric acid . .	6 parts 5 4	From + 50° to — 14°	64
Phosphate of soda . . Diluted nitric acid .	9 parts 4	From + 50° to — 12°	62
Phosphate of soda . . Nitrate of ammonia . Diluted nitric acid . .	9 parts 6 4	From + 50° to — 21°	71
Sulphate of soda . . Muriatic acid . .	8 parts 5	From + 50° to 0°	50
Sulphate of soda . . Diluted sulphuric acid .	5 parts 4	From + 50° to + 3°	47

N. B.—If the materials are mixed at a warmer temperature than that expressed in the Table, the effect will be proportionably greater; thus, if the most powerful of these mixtures be made when the air is + 85°, it will sink the thermometer to + 2°.

III.—*TABLE consisting of Frigorific Mixtures, composed of Ice, with chemical Salts and Acids.*

Frigorific Mixtures with Ice.

MIXTURES.		Thermometer sinks.		Deg. of cold produced.
Snow, or pounded ice . Muriate of soda . .	2 parts 1	From any temperature.	to — 5°	*
Snow, or pounded ice . Muriate of soda . . Muriate of ammonia .	5 parts 2 1		to — 12°	*
Snow, or pounded ice . Muriate of soda . Muriate of ammonia . Nitrate of potash .	24 parts 10 5 5		to — 18°	*
Snow, or pounded ice . Muriate of soda . . Nitrate of ammonia .	12 parts 5 5		to — 25°	*

TABLE III. Continued.

Frigorific Mixtures with Ice.

MIXTURES.		Thermometer sinks.	Deg. of cold produced.
Snow Diluted sulphuric acid	3 parts 2	From + 32° to — 23°	55
Snow Muriatic acid	8 parts 5	From + 32° to — 27°	59
Snow Diluted nitric acid	7 parts 4	From + 32° to — 30°	62
Snow Muriate of lime	4 parts 5	From + 32° to — 40°	72
Snow Cryst. muriate of lime	2 parts 3	From + 32° to — 50°	82
Snow Potash	3 parts 4	From + 32° to — 51°	83

N. B.—The reason for the omissions in the last column of this Table, is, the thermometer sinking in these mixtures to the degree mentioned in the preceding column, and never lower, whatever may be the temperature of the materials at mixing.

IV.—*TABLE consisting of Frigorific Mixtures selected from the foregoing Tables, and combined so as to increase or extend Cold to the extremest Degrees.*

Combinations of Frigorific Mixtures.

MIXTURES.		Thermometer sinks.	Deg. of cold produced.
Phosphate of soda Nitrate of ammonia Diluted nitric acid	5 parts 3 4	From 0° to — 34°	34
Phosphate of soda Nitrate of ammonia Diluted mixed acids	3 parts 2 4	From — 34° to — 50°	16
Snow Diluted nitric acid	3 parts 2	From 0° to — 46°	46
Snow Diluted sulphuric acid Diluted nitric acid	8 parts 3 3	From — 10° to — 56°	46
Snow Diluted sulphuric acid	1 part 1	From — 20° to — 60°	40
Snow Muriate of lime	3 parts 4	From + 20° to — 48°	68
Snow Muriate of lime	3 parts 4	From + 10° to — 54°	64
Snow Muriate of lime	2 parts 3	From — 15° to — 68°	53
Snow Cryst. muriate of lime	1 part 2	From 0° to — 66°	66
Snow Cryst. muriate of lime	1 part 3	From — 40° to — 73°	33
Snow Diluted sulphuric acid	8 parts 10	From — 68° to — 91°	23

N. B.—The materials in the first column are to be cooled, previously to mixing, to the temperature required, by mixtures taken from either of the preceding tables.

V.—*TABLE of Capacities of different Substances for Caloric.*

In this Table, the authorities are marked by the initials of the respective authors' names, C. Crawford: K. Kirwan: Ir. Irvine: G. Gadolin: L. Lavoisier: W. Wilcke: M. Meyer.

Gases.

1.	Hydrogen gas	21·4000	C.
2.	Oxygen gas	4·7490	—
3.	Atmospheric air	1·7900	—
4.	Aqueous vapour	1·5500	C.
5.	Carbonic acid gas	1·6454	—
6.	Nitrogen gas	·7936	—

Liquids.

7.	Solution of carbonate of ammonia	1·8510	K.
8.	Solution of brown sugar	1·0860	—
9.	Alcohol (15·44)	1·0860	—
10.	Arterial blood	1·0300	C.
11.	Water	1·0000	
12.	Cow's milk	·9999	C.
13.	Sulphuret of ammonia	·9940	K.
14.	Solution of muriate of soda, 1 in 10 of water	·9360	G.
15.	Alcohol (9·44)	·9300	Ir.
16.	Sulphuric acid, diluted with 10 of water	·9250	G.
17.	Solution of muriate of soda in 6·4 of water	·9050	G.
18.	Venous blood	·8928	C.
19.	Sulphuric acid, with 5 parts of water	·8760	G.
20.	Solution of muriate of soda in 5 of water	·8680	G.
21.	Nitric acid (39)	·8440	K.
22.	Solution of sulphate of magnesia in 2 of water	·8440	—
23.	Solution of muriate of soda in 8 of water	·8320	
24.	Solution of muriate of soda in 3·33 of water	·8200	G.
25.	Solution of nitrate of potash in 8 of water	·8167	L.
26.	Solution of muriate of soda in 2·8 of water	·8020	G.
27.	Solution of muriate of ammonia in 1·5 of water	·7980	K.
28.	Solution of muriate of soda saturated, or in 2·69 of water	·7930	G.
29.	Solution of supertartrate of potash in 237·3 of water	·7650	K.
30.	Solution of carbonate of potash	·7590	—
31	Colourless sulphuric acid (51·55,56,57)	·7580	—
32.	Sulphuric acid, with 2 parts of water	·7490	G.
33.	Solution of sulphate of iron in 2·5 of water	·7340	K.
34.	Solution of sulphate of soda in 2·9 of water	·7280	—
35.	Olive oil	·7100	—
36.	Water of ammonia, sp. gr. 0·997	·7080	—
37.	Muriatic acid, sp. gr. 1·122	·6800	—
38.	Sulphuric acid, 4 parts with 5 of water	·6631	L.
39.	Nitric acid, sp. gr. 1·29895	·6613	
40.	Solution of alum in 4·45 of water	·6490	M.
41.	Mixture of nitric acid with lime, 9½ to 1	·6189	L.
42.	Sulphuric acid, with an equal weight of water	·6050	G.
43.	Sulphuric acid, 4 parts with 3 of water	·6031	L.
44.	Alcohol (9·15)	·6021	C.
45.	Nitrous acid, sp. gr. 1·354	·5760	K.
46.	Linseed oil	·5280	—
47.	Spermaceti oil (53)	·5000	C.
48.	Sulphuric acid, with ½ of water	·5000	G.
49.	Oil of turpentine (52)	·4720	K.
50.	Sulphuric acid, with ¼ of water	·4420	G.
51.	Sulphuric acid (31·55,56,57)	·4290	C.
52.	Oil of turpentine (49)	·4000	Ir.
53.	Spermaceti oil (47)	·3990	K.
54.	Red wine vinegar	·3870	—
55.	Sulphuric acid, concentrated and colourless (31)	·3390	G.
56.	Sulphuric acid, sp. gr. 1·87058	·3345	L.
57.	Sulphuric acid (31·51)	·3330	Ir.
58.	Spermaceti melted	·3200	—
59.	Quicksilver, sp. gr. 13·30	·0330	K.
60.	Quicksilver	·0290	L.
61.	———	·0290	W.
62.	———	·0280	Ir.

Solids.

63.	Ice	·9000	K.
64.	—	·8000	Ir.
65.	Oxhide with the hair	·7870	C.
66.	Sheep's lungs	·76[illegible]0	—
67.	Beef of an ox	·7400	—
68.	Scotch fir wood	·6500	M.
69.	Lime tree wood	·2600	—
70.	Spruce fir wood	·6000	—
71.	Pitch pine wood	·5800	—
72.	Apple tree wood	·5700	—

73.	Alderwood	·5300	M.
74.	Sessile-leaved oak	·5100	—
75.	Ash wood	·5100	—
76.	Pear tree wood	·5000	—
77.	Rice	·5060	C.
78.	Horse-beans	·5020	—
79.	Dust of the pine tree	·5000	—
80.	Pease	·4920	—
81.	Beech	·4900	M.
82.	Hornbeam wood	·4800	—
83.	Birch wood	·4800	—
84.	Wheat	·4770	C.
85.	Elm	·4700	M.
86.	White wax	·4500	G.
87.	Pedunculated oak wood	·4500	M.
88.	Prune tree	·4400	—
89.	Ebony wood	·4300	—
90.	Quicklime, with water, in the proportion of 16 to 9	·4391	L.
91.	Barley	·4210	C.
92.	Oats	·4160	—
93.	Charcoal of birch wood (99)	·3950	G.
94.	Carbonate of magnesia	·3790	—
95.	Prussian blue	·3300	—
96.	Quicklime, saturated with water and dried	·2800	G.
97.	Pit coal	·2777	C.
98.	Artificial gypsum	·2640	G.
99.	Charcoal (93)	·2631	C.
100.	Chalk (108)	·2564	—
101.	Rust of iron	·2500	—
102.	White clay	·2410	G.
103.	White oxide of antimony washed	·2272	C.
104.	Oxide of copper	·2272	—
105.	Quicklime (107)	·2239	—
106.	Muriate of soda in crystals	·2260	G.
107.	Quicklime (105)	·2168	L.
108.	Chalk (100)	·2070	G.
109.	Crown glass	·2000	Ir.
110.	Agate, sp. gr. 2·648	·1950	W.
111.	Earthen ware	·1950	K.
112.	Crystal glass without lead	·1929	L.
113.	Cinders	·1923	C.
114.	Sulphur	·1890	Ir.
115.	Ashes of cinders	·1855	C.
116.	White glass, sp. gr. 2·386	·1870	W.
117.	White clay burnt	·1850	G.
118.	Black lead	·1830	G.
119.	Sulphur	·1830	K.
120.	Oxide of antimony, nearly free of air	·1666	C.
121.	Rust of iron, ditto, ditto	·1666	—
122.	Ashes of elm wood	·1402	—
123.	Iron (125.127,128.132)	·1450	Ir.
124.	Oxide of zinc, nearly freed from air	·1369	C.
125.	White cast iron	·1320	G.
126.	White oxide of arsenic	·1260	—
127.	Iron (123.132)	·1269	C.
128.	Iron, sp. gr. 7.876	·1260	W.
129.	Cast iron abounding in plumbago	·1240	G.
130.	Hardened steel	·1230	—
131.	Steel softened by fire	·1200	—
132.	Soft bar iron, sp. gr. 7·724	·1190	—
133.	Brass, sp. gr. 8·356 (135)	·1160	W.
134.	Copper, sp. gr. 8·785 (136)	·1140	—
135.	Brass (133)	·1123	C.
136.	Copper (134)	·1111	—
137.	Sheet iron	·1099	L.
138.	Zinc, sp. gr. 7·154 (143)	·1020	W.
139.	White oxide of tin, nearly free of air	·990	C.
140.	Cast pure copper, heated between charcoal, and cooled slowly, sp. gr. 7·907	·980	G.
141.	Hammered copper, sp. gr. 9·150	·970	G.
142.	Oxide of tin	·960	K.
143.	Zinc (138)	·943	C.
144.	Ashes of charcoal	·909	—
145.	Sublimated arsenic	·840	G.
146.	Silver, sp. gr. 10·001	·820	W.
147.	Tin (152)	·704	C.
148.	Yellow oxide of lead	·680	—
149.	White lead	·670	G.
150.	Antimony	·645	—
151.	Antimony, sp. gr. 6·107	·630	W.
152.	Tin, sp. gr. 7·380 (147)	·600	—
153.	Red oxide of lead	·590	G.
154.	Gold, sp. gr. 19·04	·500	W.
155.	Vitrified oxide of lead	·590	G.
156.	Bismuth, sp. gr. 9·861	·430	W.
157.	Lead, sp. gr. 11·45	·420	—
158.	——	·352	C.

The above capacities of the gases are all erroneous; and those of the other bodies are probably more or less incorrect. See Caloric.

VI.—*Correspondence of the Thermometers of Fahrenheit and Reaumur, and that of Celsius, or the Centigrade Thermometer of the modern French Chemists.*

Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.
212	80	100·	148	51·5	64·4	85	23·5	29·4	22	4·4	5·5
211	79·5	99·4	147	51·1	63·8	84	23·1	28·8	21	4·8	6·1
210	79·1	98·8	146	50·6	63·3	83	22·6	28·3	20	5·3	6·6
209	78·6	98·3	145	50·2	62·7	82	22·2	27·7	19	5·7	7·2
208	78·2	97·7	144	49·7	62·2	81	21·7	27·2	18	6·2	7·7
207	77·7	97·2	143	49·3	61·6	80	21·3	26·6	17	6·6	8·3
206	77·3	96·6	142	48·8	61·1	79	20·8	26·1	16	7·1	8·8
205	76·8	96·1	141	48·4	60·5	78	20·4	25·5	15	7·5	9·4
204	76·4	95·5	140	48	60	77	20	25	14	8	10
203	76	95	139	47·5	59·4	76	19·5	24·4	13	8·4	10·5
202	75·5	94·4	138	41·1	58·8	75	19·1	23·8	12	8·8	11·1
201	75·1	93·8	137	46·6	58·3	74	18·6	23·3	11	9·3	11·6
200	74·6	93·3	136	46·2	57·7	73	18·2	22·7	10	9·7	12·2
199	74·2	92·7	135	45·7	57·2	72	17·7	22·2	9	10·2	12·7
198	73·7	92·2	134	45·3	56·6	71	17·3	21·6	8	10·6	13·3
197	73·3	91·6	133	44·8	56·1	70	16·8	21·1	7	11·1	13·8
196	72·8	91·1	132	44·4	55·5	69	16·4	20·5	6	11·5	14·4
195	72·4	90·5	131	44	55	68	16	20	5	12	15
194	72	90	130	43·5	54·4	67	15·5	19·4	4	12·4	15·5
193	71·5	89·4	129	43·1	53·8	66	15·1	18·8	3	12·8	16·1
192	71·1	88·8	128	42·6	53·3	65	14·6	18·3	2	13·3	16·6
191	70·6	88·3	127	42·2	52·7	64	14·2	17·7	1	13·7	17·2
190	70·2	87·7	126	41·7	52·2	63	13·7	17·2	0	14·2	17·7
189	69·7	87·2	125	41·3	51·6	62	13·3	16·6	1	14·6	18·3
188	68·3	86·6	124	40·8	51·1	61	12·8	16·1	2	15·1	18·8
187	68·8	86·1	123	40·4	50·5	60	12·4	15·5	3	15·5	19·4
186	68·4	85·5	122	40	50	59	12	15	4	16	20
185	68	85	121	39·5	49·4	58	11·5	14·4	5	16·4	20·5
184	67·5	84·4	120	39·1	48·8	57	11·1	13·8	6	16·8	21·1
183	67·1	83·8	119	38·6	48·3	56	10·6	13·3	7	17·3	21·6
182	66·6	83·3	118	38·2	47·7	55	10·2	12·7	8	17·7	22·2
181	66·2	82·7	117	37·7	47·2	54	9·7	12·2	9	18·2	22·7
180	65·7	82·2	116	37·3	46·6	53	9·3	11·6	10	18·6	23·3
179	65·3	81·6	115	36·8	46·1	52	8·8	11·1	11	19·1	23·8
178	64·8	81·1	114	36·4	45·5	51	8·4	10·5	12	19·5	24·4
177	64·4	80·5	113	36	45	50	8	10	13	20	25
176	64	80	112	35·5	44·4	49	7·5	9·4	14	20·4	25·5
175	63·5	79·4	111	35·1	43·8	48	7·1	8·8	15	20·8	26·1
174	63·1	78·8	110	34·6	43·3	47	6·6	8·3	16	21·3	26·6
173	62·6	78·3	109	34·2	42·7	46	6·2	7·7	17	21·7	27·2
172	62·2	77·7	108	33·7	42·2	45	5·7	7·2	18	22·2	27·7
171	61·7	77·2	107	33·3	41·6	44	5·3	6·6	19	22·6	28·3
170	61·3	76·6	106	32·8	41·1	43	4·8	6·1	20	23·1	28·8
169	60·8	76·1	105	32·4	40·5	42	4·4	5·5	21	23·5	29·4
168	60·4	75·5	104	32	40	41	4	5	22	24	30
167	60	75	103	31·5	39·4	40	3·5	4·4	23	24·4	30·5
166	59·5	74·4	102	31·1	38·8	39	3·1	3·8	24	24·8	31·1
165	59·1	73·8	101	30·6	38·3	38	2·6	3·3	25	25·3	31·6
164	58·6	73·3	100	30·2	37·7	37	2·2	2·7	26	25·7	32·2
163	58·2	72·7	99	29·7	37·2	36	1·7	2·2	27	26·2	32·7
162	57·7	72·2	98	29·3	36·6	35	1·3	1·6	28	26·6	33·3
161	57·3	71·6	97	28·8	36·1	34	0·8	1·1	29	27·1	33·8
160	56·8	71·1	96	28·4	35·5	33	0·4	0·5	30	27·5	34·4
159	56·4	70·5	95	28·0	35	32	0	0	31	28·4	35
158	56	70	94	27·5	34·4	31	0·4	0·5	32	28	35·5
157	55·5	69·4	93	27·1	33·8	30	0·8	1·1	33	28·8	36·1
156	55·1	68·8	92	26·6	33·3	29	1·3	1·6	34	29·3	36·6
155	54·6	68·3	91	26·2	32·7	28	1·7	2·2	35	29·7	37·2
154	54·2	67·7	90	25·7	32·2	27	2·2	2·7	36	30·2	37·7
153	53·7	67·2	89	25·3	31·6	26	2·6	3·3	37	30·6	38·3
152	53·3	66·6	88	24·8	31·1	25	3·1	3·8	38	31·1	38·8
151	52·8	66·1	87	24·4	30·5	24	3·5	4·4	39	31·5	39·4
150	52·4	65·5	86	24	30	23	4	5	40	32	40
149	52	65									

TABLE VII.—*Of the Elastic Force of the Vapour of Water in inches of Mercury, by* DR. URE.

Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.
24°	0·170	115°	2·820	195°	21·100	242°	53·600	270°	86·300	295·6°	130·400
32	0·200	120	3·300	200	23 600	245	56·340	271·2	88·000	295	129·000
40	0·250	125	3·830	205	25·900	245·8	57·100	273·7	91·200	297·1	133·900
50	0·360	130	4·366	210	28·880	248·5	60·400	275	93·480	298·8	137·400
55	0·416	135	5·070	212	30·000	250	61·900	275·7	94·600	300	139·700
60	0·516	140	5·770	216·6	33·400	251·6	63·500	277·9	97·800	300·6	140·900
65	0·630	145	6·600	220	35·540	254·5	66·700	279·5	101·600	302	144·300
70	0·726	150	7·530	221·6	36·700	255	67·250	280	101·900	303·8	147·700
75	0·860	155	8·500	225	39·110	257·5	69·800	281·8	104·400	305	150·560
80	1·010	160	9·600	226·3	40·100	260	72·300	283·8	107·700	306·8	154·400
85	1·170	165	10·800	230	43·100	260·4	72·800	285·2	112·200	308	157·700
90	1·360	170	12·050	230·5	43·500	262·8	75·900	287·2	114·800	310	161·300
95	1·640	175	13·550	234·5	46·800	264·9	77·900	289	118·200	311·4	164·800
100	1·860	180	15·160	235	47·220	265	78·040	290	120·150	312	167·000
105	2·100	185	16·900	238·5	50·300	267	81·900	292·3	123·100	Another experim.	
110	2·456	190	19·000	240	51·700	269	84·900	294	126·700	312°	165·5

TABLE VIII.—*Of the Elastic Forces of the Vapours of Alcohol, Ether, Oil of Turpentine, and Petroleum, or Naphtha, by* DR. URE.

Ether.		Alcoh. sp. gr. 0.813		Alcoh. sp. gr. 0.813.		Petroleum.	
Temp.	Force of Vapour.	Temp.	Force of Vapour.	Temp.	Force of Vapour.	Temp.	Force of Vapour.
34°	6·20	32°	0·40	193·3°	46·60	316°	30·00
44	8·10	40	0·56	196·3	50·10	320	31·70
54	10·30	45	0·70	200	53·00	325	34·00
64	13·00	50	0·86	206	60·10	330	36·40
74	16·10	55	1·00	210	65·00	335	38·90
84	20.00	60	1·23	214	69·30	340	41·60
94	24.70	65	1·49	216	72·20	345	44·10
104	30.00	70	1·76	220	78·50	350	46·86
2d Ether.		75	2·10	225	87·50	356	50·20
105	30·60	80	2·45	230	94·10	360	53·30
110	32·54	85	2·93	232	97·10	365	56·90
115	35·90	90	3·40	236	103·60	370	60·70
120	39·47	95	3·90	238	106·90	372	61·90
125	43·24	100	4·50	240	111·24	375	64·00
130	47·14	105	5·20	244	118·20	Oil of Turpentine.	
135	51·90	110	6·00	247	122·10	Temp.	Force of Vapour.
140	56·90	115	7·10	248	126·10	304°	30·00
145	62·10	120	8·10	249·7	131·40	307·6	32·60
150	67·60	125	9·25	250	132·30	310	33·50
155	73·60	130	10·60	252	138·60	315	35·20
160	80·30	135	12·15	254·3	143·70	320	37·06
165	86·40	140	13·90	258·6	151·60	322	37·80
170	92·80	145	15·95	260	155·20	326	40·20
175	99·10	150	18·00	262	161·40	330	42·10
180	108·30	155	20·30	264	166·10	336	45·00
185	116·10	160	22·60			340	47·30
190	124·30	165	25·40			343	49·40
195	133·70	170	28·30			347	51·70
200	142·80	173	30·00			350	53·80
205	151.39	178·3	33·50			354	56·60
210	166·00	180	34·73			357	58·70
		182·3	36·40			360	60·80
		185·3	39·90			362	62·40
		190	43·20				

TABLE IX.—*New French Weights and Measures* (*computed by* DR. URE).

1.—*Measures of Length: the Metre being at 32°, and the Foot at 62°.*

		English inches.		Mil.	Fur.	Yds.	Feet.	In.
Millimetre	=	·03937						
Centimetre	=	·39371						
Decimetre	=	3·93708						
Metre *	=	39·37079						
Decametre	=	393·70790	=	0	0	10	2	9·7
Hecatometre	=	3937·07900	=	0	0	109	1	1·078
Kilometre	=	39370·79000	=	0	4	213	1	10·3
Myriometre	=	393707·90000	=	6	1	156	0	9·17

2.—*Measures of Capacity: Cubic inch contains* 252·5 *Imperial grains of water, at* 62°.

		Cubic inches.		*Imperial.*	
				Gallons.	Pints.
Millilitre	=	0·06112			
Centilitre	=	0·61120			
Decilitre	=	6·11208			
Litre	=	61·12079	=	0	1·76377
Decalitre	=	611·20792	=	2	1·4464
Hecatolitre	=	6112·07920	=	22	0·2640
Kilolitre	=	61120·79208	=	220·47	
Myriolitre	=	611207·92080	=	2204·71	

3.—*Measures of Weight.*

		English grains.		*Avoirdupois.*
				Pound.
Milligramme	=	·0154		
Centigramme	=	·1543		
Decigramme	=	1·5433		
Gramme	=	15·4330		
Decagramme	=	154·3300	=	0.022
Hecatogramme	=	1543·3300	=	0·220
Kilogramme	=	15433·0000	=	2·204
Myriogramme	=	154330·0000	=	22·047

TABLE X.—*Correspondence of English Weights and Measures with those used in France before the Revolution.*

§ 1.—*Weights.*

The Paris pound, *poids de marc* of Charlemagne, contains 9216 Paris grains; it is divided into 16 ounces, each ounce into 8 gros, and each gros into 72 grains. It is equal to 7561 English troy grains.

The English troy pound of 12 ounces contains 5760 English troy grains, and is equal to 7021 Paris grains.

The English avoirdupois pound of 16 ounces contains 7000 English troy grains, and is equal to 8532·5 Paris grains.

To reduce Paris grains to English troy grains, divide by
English troy grains to Paris grains, multiply by } 1·2189

To reduce Paris ounces to English troy, divide by
English troy ounces to Paris, multiply by } 1·015734

§ 2.—*Long and Cubical Measures.*

To reduce Paris running feet, or inches, into English, multiply by
English running feet, or inches, into Paris, divide by } 1·065977

To reduce Paris cubic feet, or inches, to English, multiply by
English cubic feet, or inches, to Paris, divide by } 1·211278

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* Recently determined by Captain Kater to be 39·37079 inches. (Phil. Trans. 1818, p. 109).

TABLE XI.—*Correspondence between English and other Foreign Weights and Measures.*

I.—*English Weights and Measures.*

Troy Weight.

Pound.	Ounces.	Drms.	Scruples.	Grains.	Grammes.
1	12	96	288	5760	372·96
	1	8	24	480	31·08
		1	3	60	3·885
			1	20	1·295
				1	0·06475

Avoirdupois Weight.

Pound.	Ounces.	Drms.	Grains.	Grammes.
1	16	256	7000·	453·25
	1	16	437·5	28·328
		1	27·34375	1·7705

Measures.

Gal.	Pints.	Ounces.	Drms.	Cubic. Inch.	Litres.
1	8	128	1024		3·78515
	1	16	128	28·875	0·47398
		1	8	1·8047	0·02957
			1	0·2256	0·00396

N. B.—The English ale gallon contains 282 cubical inches.

The wine gallon contains 58176 Troy grains; and the wine pint 7272 Troy grains.

II.—*German.*

71 lbs. or grs. English troy · = 74 lbs. or grs. German apothecaries' weight.
1 oz. Nuremberg, medic. weight = 7 dr. 2 sc. 9 gr. English.
1 mark Cologne . . . . . . = 7 oz. 2 dwt. 4 gr. English troy.

III.—*Dutch.*

1 lb. Dutch = 1 lb. 3 oz. 16 dwt. 7 gr. English troy.
787½ lbs. Dutch = 1038 lbs. English troy.

IV.—*Swedish Weights and Measures, used by Bergmann and Scheele.*

The Swedish pound, which is divided like the English apothecary or troy pound, weighs 6556 grs. troy.

The kanne of pure water, according to Bergmann, weighs 42250 Swedish grains, and occupies 100 Swedish cubical inches. Hence the kanne of pure water weighs 48088·719444 English troy grains, or is equal to 189.9413 English cubic inches; and the Swedish longitudinal inch is equal to 1·238435 English longitudinal inches.

By Everard's experiment, and the proportions of the English and French foot, as established by the Royal Society and French Academy of Sciences, the following numbers are ascertained:

Paris grains in a Paris cube foot of water at 55° F. = 645511
English grains in a Paris cube foot of water · · = 529922
Paris grains in an English cube foot of water · · = 533247
English grains in an English cube foot of water · = 437489·4
English grains in an English cube inch of water · = 253·175

As a cubic foot of water weighs very nearly 1000 ounces avoirdupois, the specific gravities of bodies express the ounces in a cubic foot of them, the density of water being called 1000.

TABLE XII.—*Of the Solubility of some Solids in Water.*

NAMES OF SALTS.	Solubility in 100 Parts Water.	
	At 60°	At 212°
Acids.		
Arsenic	150	
Benzoic	0·208	4·17
Boracic		2
Camphoric	1·04	8·3
Citric	133	200
Gallic	8·3	66
Mucic	0·84	1·25
Molybdenic		0·1
Oxalic	50	100
Suberic	0·69	50
Succinic	4	50
Tartaric	Very soluble	
Salifiable bases.		
Barytes	5	50
crystallized	57	Unlimited
Lime	0·2	
Potash	Very soluble	
Soda	do.	
Strontites	0·6	
crystallized	1·9	50
Salts.		
Acetate of ammonia	Very soluble	
barytes	do.	
lime	do.	
magnesia	do.	
potash	100	
soda	Very soluble	
strontites		40
Carbonate of ammonia	+ 30	100
barytes	Insoluble	
lime	do.	
magnesia	2	
potash	.25	83
soda	50	+ 100
strontites	Insoluble	
Camphorate of ammonia	1	33
barytes	0·16	
lime	0·5	
potash	33	+ 33
Citrate of soda	60	
lime	Insoluble	
Chlorate of barytes	25	+ 25
mercury	25	
potash	6	40
soda	35	+ 35
Muriate of ammonia	33	100
barytes	20	+ 20
lead	4·5	
lime	200	
magnesia	100	
mercury	5	50
potash	33	
silver	0·$\frac{1}{30}$	

NAMES OF SALTS.	Solubility in 100 Parts Water.	
	At 60°	At 212°
Muriate of soda	35·42	36·16
strontites	150	Unlimited
Nitrate of ammonia	50	200
barytes	8	25
lime	400	
magnesia	100	+ 100
potash	14·25	100
soda	33	+ 100
strontites	100	200
Oxalate of strontites	0·$\frac{1}{19}$	
Phosphate of ammonia	25	+ 25
barytes	0	0
limes	0	0
magnesia	6·6	
potash	Very soluble	
soda	25	50
strontites	0	0
Phosphite of ammonia	50	+ 50
barytes	0·$\frac{1}{4}$	
potash	33	+ 33
Sulphate of ammonia	50	100
barytes	0·002	
copper	25	50
iron	50	+ 100
lead	0·$\frac{1}{12}$	
lime	0·2	0·22
magnesia	100	133
potash	6·25	20
soda	37	125
strontites	0	0·02
Sulphite of ammonia	100	
lime	0·125	
magnesia	5	
potash	100	
soda	25	100
Saccholactate of potash		12
soda		20
Sub-borate of soda (borax)	8·4	16·8
Super-sulphate of alumina and potash (alum)	5	133
potash	50	+ 100
Super-oxalate of potash		10
tartrate of potash	1$\frac{1}{2}$	3$\frac{1}{2}$
Tartrate of potash	25	
and soda	20	
antimony and potash	6·6	33

See SALT.

NAMES OF SALTS.	DRY SALT IN 100.
Acetate of soda	60
Nitrate of soda	60
Rochelle salt	90
Nitre	74
Muriate of ammonia	50
Sulphate of nickel	65
Tartrate of potash	68
Muriate of soda	30
Nitrate of strontites	53
Sulphate of magnesia	57·5
Supersulphate of potash	?
Borax	52·5
Phosphate of soda	?
Carbonate of soda	?
Muriate of barytes	45
Sulphate of zinc	45
Alum	52
Oxalate of potash	40
Oxalate of ammonia	29
Prussiate of potash	55
Chlorate of potash	40
Boracic acid	?
Sulphate of potash and copper	40
Sulphate of copper	45
Sulphate of iron	64
Nitrate of lead	52·5
Acetate of lead	41·5
Sulphate of potash	17·5
Nitrate of barytes	26·5
Bitartrate of potash	9·5
Acetate of copper	16·5
Prussiate of mercury	35
Corrosive sublimate	?
Sulphate of soda	31·5

THE END.

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